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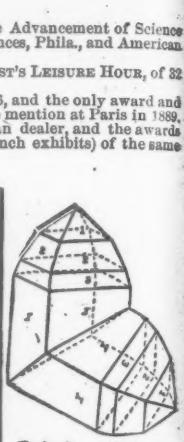

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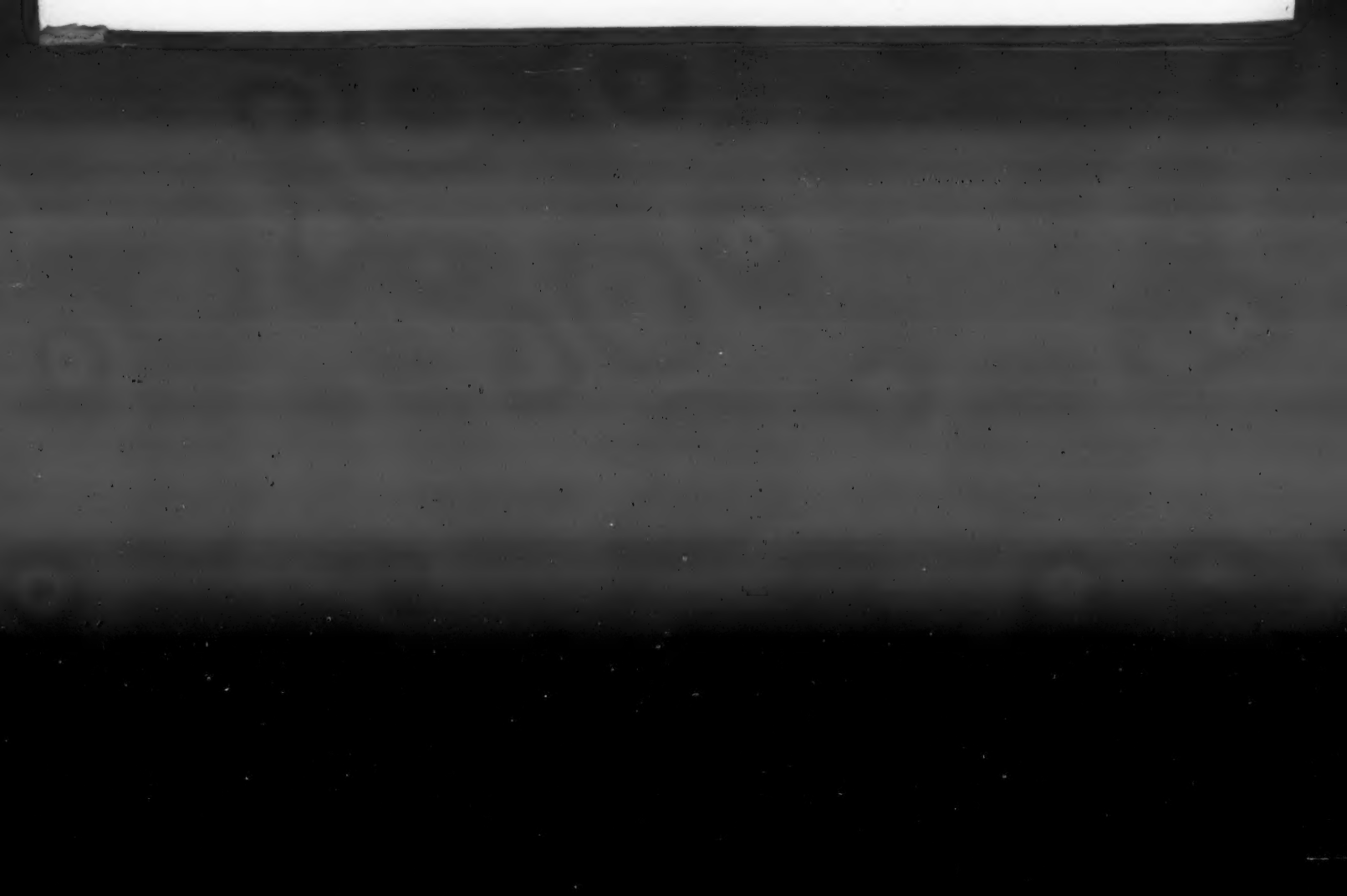


THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLIV.—*Unity of the Glacial Epoch;* by G. FREDERICK WRIGHT.

A DISTINCTION between upper and lower "drift deposits" had been observed some time before Mr. Croll and Professor James Geikie formulated their plausible theory that the ellipticity in the earth's orbit was the cause of the great ice age. But the publication of that theory with the exceedingly able advocacy of two so capable and eminent authorities gave the subject such prominence that evidences of successive glacial epochs have since been sought for in every land, while much of that adduced has been allowed to pass without as close scrutiny as would seem desirable. As I have had occasion frequently to review much of this evidence both in field explorations and in the literature of the subject, it may help to a better understanding of the matter to give somewhat fully the results of my observations and study in this direction. I would premise, however, that I shall discuss merely the glacial phenomena of the post-tertiary epoch. With the supposed evidence of glacial periods in earlier times, this paper has no concern except in a very general way.

At the outset, a question will arise as to what is meant by an "interglacial epoch." The answer to this may show that some who discuss the subject are merely considering the meaning of a word. If every temporary recession of the ice front is looked upon as an interglacial period there can be no question that there have been not merely two but a great many periods in close succession. But the position of most who advocate a succession of glacial epochs is that the continental

glacier retreated, during the interglacial epoch, to such an extent that the glaciated area was as free from ice as it is at the present time; and that subsequently the conditions were repeated and there was a re-advance to nearly the farthest limit of the previous movement. It is this view of the case which is advocated so vigorously, in this country by Professor Chamberlin and some of his associates on the United States Geological Survey, and by Professor James Geikie in Scotland, Professor Wanschaffe in Germany, Baron De Geer in Sweden and others. In discussing the problem it will be natural for me to give special prominence to the facts of the American field, and, with all respect to individuals mentioned, to the discussions and reports of my associates in the explorations of this country. But I will not wholly neglect the facts of other lands.

In approaching the subject it is important to notice the fact that Professor Chamberlin inaugurated his induction as director of the glacial division of the United States Survey by publishing a monograph on "The Terminal Moraine of the Second Glacial Epoch," thus assuming the truth of his theory in the title. In the introduction to this paper, however, nothing could be more indicative of the proper spirit with which to enter upon the discussion, or nothing more cordially welcoming discussion, than the following remarks:

"Perhaps no department of geological investigation has greater need of careful discrimination than that which deals with the complex deposits of the Quaternary age. Most formations betray their origin in their salient characteristics, but those of the Quaternary age are apparently capable of diverse interpretation if their general nature alone is considered. It is only by critical discrimination of their special and often quite unobtrusive features that they can be decisively referred to the several agencies that produced them. Most formations owe their origin to the action of some one dominant agency. The Quaternary deposits are, on the contrary, the product of a combination of agencies, the relative work of which is often distinguishable only with difficulty. In these discriminations the individual judgment of the investigator plays an important part. The influence of personal predisposition, therefore, is here liable to be most gravely felt. Probably no investigator is entirely free from the influence of his own preconceptions and methods of interpretations. He, perhaps, does best, who, while duly appreciating these influences and assiduously applying checks for their correction, frankly submits his methods of interpretation to the correction of others."

That Professor Chamberlin has kept his mind open to further light is abundantly evident by comparing his account of "the terminal moraine of the second glacial epoch," in this preliminary paper, with that which appears in his later publications, while at the same time such a comparison is suggestive of possible mistake in his whole interpretation of the facts bearing on the duality of the epoch. In this preliminary monograph (see pp. 322–326) the moraine is made to correspond with the kettle moraine of Wisconsin, and to hug the southern shore of Lake Michigan, but in the Seventh Annual Report of the U. S. G. Survey the later glacial drift is carried down to Bloomington more than a hundred miles farther south, while at the latest date Mr. Leverett (Am. Geol. July, 1892, p. 23) specially deputed by Professor Chamberlin to look after the moraines, draws his later moraine line one hundred miles still farther south, through Litchfield, Hillsboro, Pana, Shelbyville, Mattoon, Charlestown, Paris and Terre Haute. From other information I have evidence that probably this moraine will have to be carried, at least, twenty-five miles still farther south to Greenville, which will be less than 80 miles from the extreme limit of glaciation as determined by me. From this it seems not unlikely that in the near future the closer observation which has found an exterior moraine 200 miles farther south than was at first supposed to mark the limit of the second age, may carry it fifty or sixty miles farther south still, which would be all that it is necessary to make the extreme boundary stand related to the moraine there as it does throughout the eastern part of the Mississippi Valley. This result is the more likely to occur since for a hundred miles or more the whole border of the glaciated area in the valley of the Mississippi is so deeply covered with loess that the determination of moraine deposits is peculiarly difficult. Mr. Leverett has already found twelve receding moraines in Ohio—the outer one extending to within a few miles of the glacial boundary. When as many are found in Illinois it will, at the existing rate of separation, carry the line as near the border in that State.

The facts pointing toward a separation of the glacial period into two distinct epochs are thus stated by Professor Chamberlin in his monograph on the Driftless Area (pp. 214, 215). "The earlier drift is characterized in the interior basin, [1.] by a wide but relatively uniform distribution, manifesting only occasional and feeble tendencies to aggregation in morainic ridges. [2.] It is not bordered, except in rare instances, by a definite terminal moraine, but ends in an attenuated border. [3.] It is not characterized by the prevalence of prominent drumlins or other similar ridged aggregations. [4.] The phe-

nomena of glacial erosion connected with it are generally feeble. Glacial striæ are indeed present, even in the peripheral portion, but the surface of the rock is not usually extensively planed. [5.] The whole aspect of the deposit indicates an agency which spread the drift over the surface smoothly, and relatively gently, with little forceful action. The drainage phenomena are also of the gentle order. We have yet failed to find evidence of very vigorous drainage connected with the older drift of the interior basin except in osars and kames, whose conditions of formation were exceptional, but, on the contrary, abundant proof of slow-moving waters and imperfect drainage, indicating low slope of the surface.

"The later glacial epoch, on the contrary, was characterized by strong glacial action, planing the rock surface vigorously, even up to the very limit of its advance. The glaciers ploughed up immense moraines about their edges, except on smooth plains whose slope was away from the ice movement. The drainage was usually vigorous, and immense trains of glacial gravel stretch away from the margin of the ice-sheet, reaching great distances down the valleys and frequently filling them to great depths with well assorted material. The vigorous action of the glaciers of the second epoch and the rapid drainage, in general stand in marked contrast with the gentle action and imperfect drainage of the earlier epoch. One of the conditions that determined the distinction was probably the difference in elevation that characterized the two epochs.

"The interval between these two leading epochs we regard as the chief interglacial epoch, representing a greater lapse of time and a greater change in the dynamic agencies of the age than the several other interglacial intervals, or episodes of deglaciation, which mark the complicated history of the ice age.

6. "As belonging to the earlier glacial epoch, we recognize two drift sheets that have been described by the geologists of the respective states as occurring in Southwestern Ohio, Southern Indiana, Central and Southern Illinois, Eastern and Southern Iowa, Northern Missouri, Eastern Nebraska, and Southeastern Minnesota.

"Between these occur, at numerous points, vegetal and ferruginous accumulations, and other evidences of a non-glacial interval. To this horizon belong the larger number of deposits described under the term 'old forest bed,' but very many vegetal deposits so referred do not, in our judgment, belong there, but are referable to several distinct horizons."

7. Another supposed proof of a glacial period long preceding that during which the moraine of the so-called "second glacial epoch" was deposited is the greater oxidation of the glacial drift south of this moraine. This is prominently men-

tioned by Professor Salisbury as among the features "long since recognized by Professor Chamberlin" and which "have been made use of by him and his assistants in field determination." (Bull. Geol. Soc. Am., vol. iii, pp. 181, 182. Also Annual Report of the State Geologist of New Jersey for 1891, pp. 103–108.) Contrasting the earlier with the later drift as seen at Little York, Oxford Furnace, High Bridge and Pattenburg (points from three to fifteen miles south of the moraine as laid down by the New Jersey Report of 1878), Professor Salisbury says, "While the one exhibits oxidation, leaching and disintegration in an advanced stage of development even to its base, where it is thirty feet thick, the other has not suffered oxidation and leaching on any such scale as to make them apparent more than two or three feet from the surface, and the softest and most easily disintegrated varieties of rock often present a degree of freshness which, so far as the eye can see, might characterize masses of rock worked out of their parent ledges within the memory of living men. We hold, therefore, that this extra-morainic drift represents the remnant of a drift covering once much more extensive and more uniformly present than now, and that, like the drift in and north of the great terminal moraine, it was formed by an ice sheet, but by an ice sheet which overspread New Jersey much earlier than that which made the terminal moraine and the main body of drift, which lies north of it." (N. J. Ann. Rep. 1891, p. 105.) Similar remarks are repeated in even more confident tone in the Bulletin of the Geological Society already referred to.

8. Another indication of the great separation in time between the first and the second glacial period, adduced by Professor Chamberlin, presents itself in the extent of erosion which he supposes to have taken place in the river valleys extending southward from the glaciated area, since the upper terraces containing glacially transported material were formed. (Some Additional Evidences bearing on the Interval between the Glacial Epochs, Bull. Geol. Soc. Am., vol. i, pp. 469–480.) In the Mississippi Valley the upper terrace assigned by Professor Chamberlin to the first glacial period consists of the fine silt or lœss deposited on bluffs about 200 feet above the present river bottom. Between the deposition of this silt and the second glacial epoch, according to Professor Chamberlin, a trench about 300 feet in depth and about sixty miles wide was eroded by the Mississippi all the way from Cairo to the Gulf, "with corresponding erosion trenches along the upper branches during the interval between the two epochs" (p. 471). In the upper Ohio valley these high level terraces correspond to what I had assigned to the effects of the supposed glacial dam at Cincinnati. In the valleys of the Susquehanna and the Dela-

ware they correspond to what Lewis denominated the Philadelphia Red Gravel and Brick Clays, and what McGee calls Columbia.

9. Finally, strong confirmatory evidence of a long interglacial epoch is supposed to come from the desiccation of the lakes which have occupied the great arid basin in the United States west of the Rocky Mountains, of which Lakes Bonneville and Lahontan are examples.

Taking up these points in the order mentioned it may be noticed—

1. That on either theory the glacial deposits near the margin are the older, and may be a great deal older than those farther back. How long the glacial conditions continued is an open question, as is also that of how slowly it retreated during its various stages, though it probably was pretty rapid as compared with the advance. Again, it is as much in place for the advocate of the unity of the glacial period to suppose a subsidence in the valley of the Mississippi and elsewhere at the time of the climax and during the earlier retreat, coupled with a re-elevation towards the close, as for the advocates of duality to suppose the same earth movements in connection with two periods. Therefore the "relatively uniform distribution" of the marginal drift, may be accounted for on one theory as well as on the other. On either theory the marginal drift has been longer subjected to erosive and leveling agencies, and, on account of the submergence during the climax of the period, the deposition of læss has done much to disguise the surface features. I can cite a locality near Yankton, S. Dakota, where the original irregularity of the morainic drift was completely disguised by the superficial water deposits which were altogether above the reach of any present stream. Kettle holes have there been filled up with silt and were only revealed in the process of obtaining the sand for commercial purposes. At Sarahsville, in Williamson County, Illinois, within a few miles of the extreme border of glacial deposits there is a section showing ten feet of læss upon the surface underlaid by twenty feet of till containing granitic bowlders two and a half feet in diameter. (See my report in Bull. Geol. Surv., No. 58, p. 71, on Southern Illinois.) Until all that region is explored with much more minuteness than it has been so far, it is proper to regard the generalizations which are made about it with a good deal of allowance for the personal equation of the observer.

2. The fact that the oldest part of the glaciated region "is not bordered by a definite terminal moraine, but ends in an attenuated border," is only another way of stating the fact which Lewis and I began to urge upon the attention of the

public ten years ago during the early part of our investigations. In the map of the glacial boundary prepared for my volume on The Ice Age in North America (p. 175), the legend for the line marking the border of the glaciated area west of Pennsylvania, is not "terminal moraine," but simply "southern limit of the ice sheet." East of that point, indeed, a moraine is marked as the boundary, but emphatic attention is called, both in my own language and in that of Professor Lewis, to the probability that here also an unexplored border of thinner glaciated material is to be found south of the moraine. (Ice Age, p. 135.) Recent observations enable me to determine the extent of this "fringe" as we proposed to call it, in the Delaware and Susquehanna valleys, and to give an entirely different interpretation to certain facts in that region from that proposed by Professor Salisbury in support of his theory of a prolonged interglacial period. Of this I will speak under No. 7. Suffice it here to say that the word "fringe" seems a fair term to apply to such a bordering formation whose character is still in dispute. Professor Chamberlin's phrase, "attenuated border," would, however, be equally good. But to insist on calling it the drift of the first glacial epoch is to beg the whole question in the terms chosen, and tends to serious confusion of the public mind as to what the facts really are. The facts are well stated in the sentence quoted from Professor Chamberlin. But it would seem that occasionally in the discussion inferences are mistaken for facts of observation. For example, it is pretty generally assumed in the discussion that originally there was a much greater amount of drift over the attenuated border than there is now and that this has largely disappeared by erosion. But there does not seem to be adequate ground for this supposition. A pronounced terminal moraine is by no means a necessary result of an ice occupation. The extent of the deposits of till and other morainic material, depends in large measure upon the amount of ice movement which has actually reached a given point, which, in turn, depends on the time during which the front of the ice remained stationary at a given point. If there was a gradual approach to a given boundary and a gradual retreat after a pause of moderate length we could not expect a large accumulation of drift. It is too often forgotten that the ice movement diminishes to zero at the very border and that for some distance back of the border all the effects of the movement are specially feeble. A fringe of direct glacial deposit would, therefore, seem to be the normal result near the border. By "fringe" is meant an "attenuated border" of direct deposits from land ice such as might naturally occur near the limit of an ice invasion. This, which was at first supposed to be characteristic only of the Mississippi

Valley, is now found to be equally characteristic of the region east of the Alleghenies.

3. The lack of drumlins and other ridged accumulations along the glaciated border need indicate only a small amount of ice movement over the region, or a depressed slack condition of drainage which, as already stated, may be supposed in case of one glacial period as well as of two.

4. The feebleness of glacial erosion over the fringe follows from the reasons already stated. Of course there was less movement over the fringe than farther back. Still that there was some vigorous movement close to the very margin is shown by the glacial striæ which I have reported from Carbondale, Ill. and from St. Louis, Mo. (See Bull. Geol. Surv., No. 58, pp. 71–73). Dr. Max Foshay has also discovered very pronounced groovings in Western Pennsylvania in the area covered by the fringe several miles south of the moraine as there laid down by Professor Lewis and myself.

5. The fifth point is in part a mere repetition of the first, and to some extent the reply will be the same. The slack drainage indicated in the deposits near the border was caused probably by the changes of level which have been connected with the Champlain epoch. A part of this evidence of slack drainage is found along the Susquehanna and Delaware Valleys, in the Columbia deposits of Mr. McGee. A natural supposition is that the climax of the period was characterized by a depression of land considerably greater than is indicated by the level of the deposits in the Champlain Valley at the time of the disappearance of the ice. But as this point involves a theory concerning the cause of the period and of the changes of level attending it, a few paragraphs may well be devoted to a fuller statement of the reasons for believing that a subsidence may naturally be supposed to have attended the climax of the epoch on the supposition that it was single.

Whatever subsidiary aid the eccentricity of the earth's orbit may provide for the production of glacial conditions, there is now little doubt that the ice age was introduced and closed by marked changes of level, both in North America and in Northern Europe. The fiords which characterize the coast of Norway, and which are brought to light by the sounding line along both the Atlantic and the Pacific coast of North America bear striking witness to the extent of this elevation during the period just preceding the glacial epoch. (See Appendix to The Ice Age in N. A by Warren Upham.) So great was this late Pliocene elevation that it seems to many that it might have been sufficient to have produced the glacial conditions of the succeeding age even without the aid of astronomical changes. An elevation of 3,000 feet would probably

be sufficient, and this is much less than we know has occurred in central Europe since Miocene times. Miocene shells are found on the Alps and Pyrenees at an elevation of more than 10,000 feet. An elevation of our glaciated region in its northern parts of 3,000 feet is therefore not out of analogy with the movements during contiguous eras.

Supposing therefore the elevation of the region south of Hudson Bay to amount to 3,000 feet, this would provide the conditions necessary for the beginning of an ice age. But when such a career is once started it is difficult to imagine how it can stop, for the accumulation of ice at once lowers the temperature and adds to the elevation of the surface of the plateau on which it rests; thus tending to increase the depression of the land. The ice piles up and makes an elevation of its own, additional to that of the land, and overloads it with its own weight.

There is certainly much plausibility in the supposition that the subsidence which accompanied the glacial period, and from which the continents have not yet fully recovered, was in part due to the weight of the ice piled up over the glaciated area. The conditions were then unique in the geological history of the earth. About 4,000,000 square miles of territory in the northern part of North America and about half that amount in Northern Europe were covered with ice averaging, probably, three-quarters of a mile in depth, making in all 5,500,000 cubic miles of ice whose weight had first been abstracted from ocean beds, thus relieving the pressure there, and then centered over a restricted area at the north. The relative extent of this disturbance of equilibrium can be appreciated only by comparing this mass of ice with the solid contents of that portion of the continent which is above ocean level. The mean elevation of North America above the sea is estimated by Wallace (Island Life, p. 205) to be 748 feet, while the total area is less than 9,000,000 square miles. This would give about 1,300,000 cubic miles of land in North America above the water level, as against 3,000,000 cubic miles of ice over the northern half of the continent during the climax of the glacial period. Taking the specific gravity of the rocks as two and a half times that of ice, the total weight of ice piled up over British America and the Northern United States, at the time referred to, was nearly equal to that of the whole land surface of the continent which is above sea level. That this enormous change in the distribution of weight and pressure on the surface of the earth should occur without any effect on the configuration of the globe is difficult to believe. When therefore we find that extensive changes in level seem actually to have been correlated with this loading

and unloading of the strata which took place during the progress of the glacial age, it is not a wholly unwarranted step in reasoning to connect the two as cause and effect. The supposition, therefore, of a marked subsidence of the northern part of the continent contemporaneous with the climax of the period is a fair one to use in explanation of the complex phenomena of the time.

To appreciate the degree of probability attending the explanation, however, it is important to consider still more closely the natural operation of the forces at work. Upon doing this it is evident that glacial conditions would continue some time after the land subsidence had begun. For a long period the accumulation of ice might be faster than the subsidence of the plateau on which it rested. The anticlimax, when the melting began to proceed faster than the accumulation, was doubtless reached only after a very prolonged period. But when the tide of affairs had really turned and the land had begun to rise the melting of the ice had also progressed to a great extent and the final ending up of the period and the return of the land to a higher level doubtless proceeded with great relative rapidity. On this provisional hypothesis most of the facts indicating slack drainage during the deposition of the marginal deposits will be as readily explained as on that of two distinct epochs with different attitudes of land level during their existence.

6. The occurrence of vegetal and ferruginous accumulations between successive strata of glacial deposits, has long attracted wide attention. At first these were taken to indicate interglacial periods of wide extent and of long separation in time. The occurrence of such deposits seems to be still the chief reliance of many European geologists, as well of some in this country, for belief in successive glacial periods. Professor Chamberlin, however, is not among those who place undue reliance upon this class of evidence, as the quotation from him already given shows; for in his judgment very many of the vegetal deposits occurring in the till "are referable to several distinct horizons." The hazard of inferring a prolonged interglacial epoch from such deposits, also very forcibly appears in view of some recent facts brought to light by study of the glaciers of Alaska.

In this Journal for January, 1887 (pp. 11 to 15, more fully stated in The Ice Age of N. A., pp. 51–62), I have given the facts concerning certain buried forests at the mouth of the Muir Glacier which are standing in undisturbed strata of sand and gravel, from which the ice is slowly withdrawing. I adduced evidence also to show that the ice front had withdrawn several miles during the present century, uncovering

forest beds on its way. These inferences have been fully confirmed by the investigations of Professors Reid and Cushing who spent the summer of 1890, on the same ground (see National Geographic Magazine for March, 1892, and The American Geologist for Oct., 1891). Indeed Professor Reid's photographs show that the ice front had receded 3,000 feet during the four years intervening between our visits and he is confident that the glacier has receded fourteen miles during the century. These observations reveal also unexpected rapidity in the movements of great glaciers and remarkable capacity of ice in certain conditions to creep over unsolidified strata of sand and gravel without disturbing them. From the rapidity with which both forests and ocean fauna follow up a retreating ice front where, as in this case, it debouches into an arm of the sea, it is clear that two or three centuries are sufficient to produce a forest bed of considerable extent with all its accompaniments of glacial deposits below and above.

In addition to this Mr. Russell (National Geographic Magazine, vol. iii, p. 92, Am. Geologist, March and May, 1892; and this Journal, March, 1892) reports from the great Malaspina glacier, whose foot spreads out over an area of 1,500 square miles on the low lands southeast of Mt. St. Elias, that on the belt of morainic accumulations which conceal the extreme margin of the glacier for a width of five miles or more there is a dense forest growth. This forest has every appearance of considerable age. It consists principally of spruce trees, some of which are three feet through, but there are many alders "and a great variety of shrubs and bushes, together with rank ferns which grow so densely that one can scarcely force a passage through them." (This Journal, p. 178.) In many places this vegetation is on a moraine which is underlaid by ice not less than a thousand feet in thickness. These forests appear also on the north border of the glacier. The whole area of ice observed by Mr. Russell to be covered by forests was estimated at from twenty to twenty-five miles. Such facts as these should make us hesitate about attributing every forest bed buried in glacial deposits to a distinct glacial period. In the complicated movements which doubtless attended the advance and retreat of so vast an ice sheet there is room for the burial of a great many forest beds, and Professor Chamberlin is doubtless correct in thinking that those discovered in the Mississippi Valley may belong to several different horizons. In my "Ice Age" (pp. 484–488), I have quoted at length from the late Mr. Lesquereux to show that two or three hundred years is ample time to allow for the accumulations of peat which have been found embodied in glacial deposits. (See also Penn. Ann. Geol. Report for 1885, pp. 106 to 114.)

From the discussions in the International Congress of Geologists at Washington in 1891, it would appear also that a fair share of the European members did not regard the interstratified gravel deposits of North Germany as indicative of anything more than a temporary oscillation of the ice. (See Am. Geol., Oct., 1891, pp. 241 to 247.) The "interglacial shell beds" at elevations of 1,000 and 1,400 feet above sea in England at Macclesfield and Moel Tryfaen, have been shown to be shells pushed up from the Irish Sea, and washed out and stratified in thin beds by the local streams of water accompanying the departure of the ice sheet. (See my paper in this Journal, Jan. 1892; but especially Professor Kendall's comprehensive discussion of the evidence in my volume just published by D. Appleton & Co., entitled Man and the Glacial Period, pp. 136–182.) Professor Lewis's conjecture seems to be amply sustained by subsequent investigations. The evidence for a succession of glacial periods in Great Britain is inconclusive, while the evidence against it is overwhelming. Professor James Geikie has indeed recently returned to the defence of his favorite theory (see On The Glacial Period and the Earth Movement Hypothesis, being a paper read before the Victoria Institute, London), in which he relies almost wholly upon evidence of successive glacial periods to prove that the astronomical theory, to which we have referred, is the only adequate cause. His evidence is largely drawn from interglacial beds on the continent of Europe containing remains of plants and animals. The strongest instance adduced by him is still that of the interglacial lignite beds of Dürnten and Utznach in Switzerland. But it would seem that the inference of great oscillations of climate which he draws from the character of the vegetation composing the lignites rests upon very uncertain data. The remarks of Professor Prestwich upon the deposits are of great weight:

"Admitting the fact that the Dürnten Lignites rest on beds of undoubted glacial (ground moraine) origin, and that the trees grew on the spot where their stumps and remains are found, it by no means follows, as contended, that because these trees are all of species now living in Switzerland that the temperature was as high as that of Switzerland at the present day. *The Pinus sylvestris*, *Abies excelsa*, the Yew, the Birch, and the Oak, flourish equally in Sweden and far north in Siberia, and there is an absence in the scanty Dürnten flora of those plants which, while having a more southern range, also now live in Switzerland. On the other hand, there is there one species of *Pinus* (*P. Montana*) which is spread over the mountain country up to heights of 7,000 feet, and is rare in the lowlands, while one of the mosses in the lignite is

closely allied to a species now growing on the hills of Lapland. The few species of mammalia have a distinctively arctic facies. The *Elephas primigenius*, *E. antiquus*, the *Ursus spelæus*, and even the *Cervus elaphus* and *Bos primigenius*, are commonly associated with Reindeer, Musk-ox, and other arctic animals of cold post-glacial times. Further, both the trees and animals are those of our "forest bed," the last land survival before the climax of the glacial period.

"Is the return, therefore, of the retreating glacier,—supposing the boulder gravel above the lignites of Dürnten to be due to direct ice action,—to be ascribed to anything more than a comparatively slight temporary change of climate, like those, only more marked, that now for a succession of seasons cause, from time to time, a temporary advance of the glaciers? We must allow, of course, for greater differences, and possibly longer intervals of time than now obtain." (Geology, vol. ii, pp. 458, 459.)

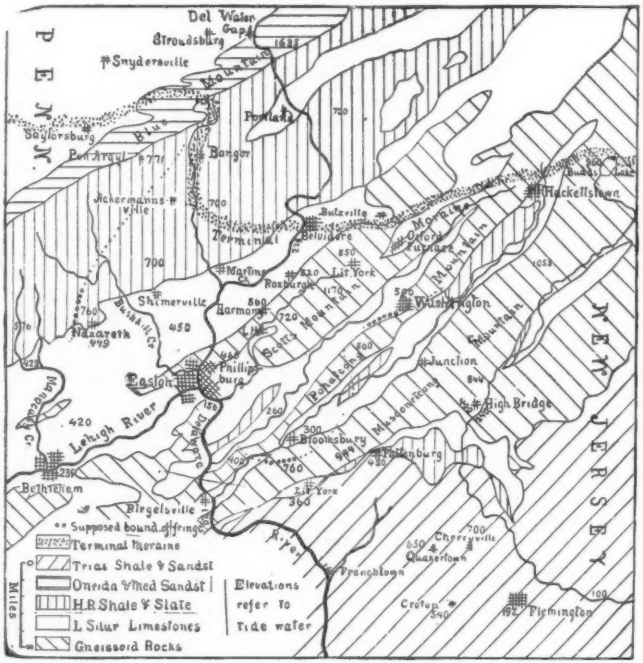
I have elsewhere called attention to the semi-arctic facies of the vegetation found in our own interglacial beds. (See Ice Age in N. America, pp. 482–496.)

7. The supposed proof of the great age of the marginal deposits drawn from their superior oxidation, is partly an illusion of observers and partly a normal result of the fact that the continental glacier moved over a region which was at the start deeply covered with oxidized material derived from the long secular disintegration which had preceded. The results of this secular disintegration are abundantly evident everywhere south of the glaciated area, especially over the regions containing granitic and gneissoid rocks. For scores and sometimes for hundreds of feet in depth these rocks are frequently so disintegrated by the long continued percolation of water charged with acids, that the mass is as loose in texture as a gravel bank. (See especially "On the Formation of Bowlders and the Origin of Drift Materials" by L. S. Burbank, in Proc. Bost. Soc. Nat. Hist., Nov. 19, 1873; also a paper by Professor Pumpelly, in this Journal, 1879, pp. 13–14. A valuable summary of discussions upon this important point is given by Mr. Ralph S. Tarr in the American Geologist for July, 1892.) Naturally the material first and farthest moved by the ice would be this which was already well oxidized to begin with. To this cause there can be little doubt is to be ascribed the oxidized character of the material contained in the "fringe" and of that composing the Philadelphia Red Gravel and Brick Clay, which is the overwash of the ice sheet when it was at its climax and when the drainage was sluggish from the differential northward depression which characterized that portion of the period.

The extensive oxidation spoken of by Professor Salisbury in the quotation made from his recent reports on the glacial deposits of New Jersey, is clearly of preglacial origin. In company with Professor A. A. Wright (a very competent geologist and mineralogist who is familiar with the region described by Professor Salisbury) I have, during the past summer, gone over the field pretty thoroughly so as to complete work which the late Professor Lewis and I had contemplated before his death. The area is that occupied by the southern part of Morris county and the northern part of Hunterdon county, New Jersey, and Northampton county, Pennsylvania. These counties border the Delaware River below the terminal moraine as delineated by the New Jersey geologists in 1878 and by Professor Lewis and myself in 1880 and 1881. Until recently this moraine has stood as the southern boundary of the glaciated region, and has been regarded as a place where there was no fringe and where the glacial moraine of what was called the "second glacial epoch" coincided with that of the first. It is fair to say, however, that this part of our work was done by Professor Lewis and myself at the outset of our attempts to trace the glacial boundary and that we then shared with others the supposition that the boundary was everywhere marked by a distinct terminal moraine.

But in the progress of our work we had our attention called more and more to an attenuated border which we called the "fringe" and which I have attended to almost exclusively in my later explorations of the boundary in the Mississippi Valley. In commenting upon this fringe Professor Lewis (see 2d Penn. Geol. Surv. Rep., vol. Z, p. 201) remarks that traces of this "fringe" may be looked for in Pennsylvania and New Jersey, and that the impression had grown upon him "that this fringe is destined to play an important part in glacial geology." Professor Lewis's early death prevented his following out the clues already then in mind, and I have been unable until the present season to examine the region with sufficient care to enable me confidently to say anything about it. Nevertheless, in view of what Mr. McGee has been writing about the Columbia deposits I ventured three years ago to utter a warning, and to suggest that he might be drawing some unwarranted conclusions from the facts he was presenting, in view of the probability that some of his facts belonged to the fringe which Professor Lewis and I had overlooked in that region. (See Ice Age in N. A., p. 135.) I am now able to demonstrate that both Mr. McGee and Professor Salisbury have been led astray in their recent publications by their failure to notice some of the characteristics of the "fringe" in the Delaware valley.

The true glacial deposits in the Delaware valley below the Water Gap can be readily traced by the distribution of Medina sandstone which forms the crest of Blue Ridge, rising everywhere as a solid wall about 1,000 feet above the country to the south. This is a very characteristic and enduring rock,



Map of the Delaware valley in the vicinity of the Terminal Moraine.

and forms a large part of the moraine in the counties mentioned. South of the moraine, on the New Jersey side of the Delaware, within a distance of fifteen miles, there are three low mountain ridges (Scott's, Pohatcong and Musconetcong) separated by valleys. These ridges and valleys run northeast by southwest parallel with Blue Ridge. The mountains consist of gneissoid rocks, and are evidently the remnants of three anticlinals which were once covered with strata of Lower Silurian limestone and Hudson River slate, remnants of which appear both in the hollows between the ridges and on both the north and their south flanks of the ridges as a whole. South of Musconetcong Mountain stretch the Triassic red shales which cover so much of the central part of New Jersey. But

in this portion of the state there has been absolutely no transportation of northern material out upon the Triassic shales, showing that no glacial movement here ever passed Musconetcong Mountain.

These Archæan ridges everywhere exhibit remarkable effects of secular disintegration. Gneissoid bowlders are creeping down their sides in all directions of slope, and, in favorable places for observation, the rock is seen to be disintegrated to a great depth. Many cuts show that the softer material is washing out and working down toward the valley, and leaving the harder masses to follow at a slower rate. Doubtless the original height of the mountain has been thus reduced thousands of feet, thus entirely removing the covering of lime and slatestone. We have here now but the cores of the original ranges. But guided by the material transported by what we may call the Delaware River lobe of the ice sheet, we find that in the vicinity of the river the ice actually overran Scott's Mountain as far east certainly as Bethel, and left Medina bowlders in considerable numbers in the Pohatcong Valley near Washington. The actually transported material here cannot be distinguished in its oxidation from that in the moraine north of Oxford Furnace. The oxidation of which Professor Salisbury speaks at Oxford Furnace and Little York is the secular oxidation which we have described as characterizing the whole mountain. But with this local material at the places mentioned there is mingled on the surface a considerable deposit of the northern rocks belonging to the fringe. The ice here barely went over Scott's Mountain to Washington. It did not here cross Pohatcong Mountain so as to reach Musconetcong Mountain.

Nearer the river, however, it crossed the low Pohatcong ridge also and, at one point, about five miles south of Philipsburgh, reached a col in Musconetcong Mountain, landing there a good many Medina bowlders, and allowing some of them to be carried down a small streamlet on the south side which for a time offered an outlet for the drainage in that direction. That the ice did not extend farther is shown by the fact that there is absolutely no transported material out on the Triassic rocks beyond the influence of this little stream, and in the case of that, the Medina pebbles have all worked down towards the Delaware River.

On the west side of the Delaware, below the moraine, there is a similar extension of the phenomena of the fringe; as there is also in the Valley of the Susquehanna below Berwick. To obtain the sections of these river valleys given by Mr. McGee to prove a subsidence in that region of several hundred feet during the Columbia (Philadelphia Brick Clay)

period (see this Journal, vol. cxxxv, pp. 376–379) he has certainly gone above the boundary of the fringe, and confounded direct glacial deposits with those made by the flooded streams of the period.

At Pattenburg and High Bridge there are cuts in deposits which at first look very much like true till, and they have been adduced by Professor Salisbury as unquestionable instances of its occurrence at these points, which demonstrate by the oxidation its great age. But a fact which Professor Salisbury failed to notice would seem to be fatal to his theory. There is no foreign material in the cuts; at least Professor A. A. Wright and I could not find any. All the fragments of the rock found in them are from the strata which have demonstrably been in place in the mountain, and may have worked down in the course of the slow disintegration to which it has been subjected since the beginning of Mesozoic time. An additional proof of this is that there is a significant cessation of Medina bowlders before reaching the north side of Musconetcong Mountain in the vicinity of both these places. There are, it is true, in the deposits many pieces of slate which are scratched as in true till, and very rarely there is a bowlder of gneissoid rock which shows faint scratches on some of its faces. But in all these cases it is impossible to tell whether the scratching has been done by an ice movement or by land slides and by the slower process of "creep," which is everywhere going on in the region. In both these places the mountain in close proximity rises several hundred feet above the deposits, and bowlders are creeping down from them. Taking the whole situation into view it seems far more probable that these deposits are the product of the degrading agencies at work in wearing down the mountain than that a northern ice sheet should have suddenly ceased to deposit Medina bowlders upon reaching the vicinity of this mountain, unless the ice ceased to move any farther. If there had ever been any such amount of Medina sandstone mingled with local material as is found in the moraine at Oxford, or at Little York, no lapse of time could have eliminated it. For this sandstone is far more enduring than the slate of which there are so many fragments both at High Bridge and Pattenburg. The evidence relied upon by Professor Salisbury from the excessive oxidation of these deposits is thus seen to be illusory. He has misread the facts.

8. The most weighty considerations favoring the duality of the glacial period are found under the eighth head. Yet it is more than possible that the apparent conclusiveness arises from an incomplete comprehension of the facts which confessedly are of a very complicated character, and but imperfectly known.

In the present state of evidence as made known to the general scientific public it is difficult to discuss the progress of events since the beginning of the glacial period in the lower Mississippi Valley. But according to Professor Chamberlin what is called the Orange Gravel and has heretofore been regarded as of glacial age, is preglacial. It does not contain granitic pebbles. His study of the deposit also convinces him that it was originally continuous over the entire trough which has a width of about sixty miles (Bull. Geol. Soc. Am. p. 471). The only relic of the earlier glacial deposits which he would recognize over this area is the silt which everywhere caps the Orange Sand and extends beyond it to the east. This he would connect with the lœss in the upper part of the valley extending to the moraines. Apparently he does not regard this silt as a deep water deposit but as a deposit spread out over a vast flood plain when the drainage was slack both from a depression northward and from the previous filling up of the trough by the Orange Sand. But granting that this is the correct interpretation of the phenomena, it is difficult to see how the erosion is shown to be "interglacial." If that depressed condition of things occurred at the climax of the period, why may not the erosion simply gauge the time since that climax? I will, however, leave others more familiar with the facts to discuss the various assumptions underlying the argument from the Lower Mississippi, and turn to the problem of erosion and deposition in the valley of the Ohio River of which I have more personal knowledge.

In brief the facts are that the Ohio occupies a trough, from three to five hundred feet in depth and averaging from a half mile to a mile in breadth, which has been eroded from nearly parallel strata of Palæozoic time. Nor does the present depth of the trough represent the whole extent of erosion. The channel is filled with gravel to a depth of from fifty to a hundred feet or more below the low water mark. Two sets of terraces containing granitic, and therefore glacial, drift mark this trough all the way from Louisville to the head-waters of the Allegheny River up to a level between 1,000 and 1,100 feet above tide. The lower terrace is continuous and is definitely traced up all the northern tributaries to the terminal moraine and is much higher and coarser near the moraine, and wherever tributaries come into the Ohio from the glaciated region, than it is below. This terrace rises at its highest points to about 120 feet above low water mark, that being the height at Cincinnati and at the mouth of Beaver Creek in Western Pennsylvania. Evidently the channel was at various places originally filled up to this height so as to raise the water level by that amount all the distance above Cincinnati.

The second series of terraces connected with the glacial period occur in various oxbows and on numerous shelves of rock bordering the channel at elevations of from 200 to 300 feet above the present river level and at about 1,000 feet above tide. Two of the best known localities are Bellevue about five miles below Pittsburgh, and Parker about thirty miles up the Allegheny from Pittsburgh.

The glacial terrace at Bellevue is 300 feet above the river, and is supported by a shelf of rock about one half mile wide. At Parker the glacial deposits are in a deserted oxbow of the river formed when the level was 200 feet higher than now. Up the Monongahela River there are corresponding terraces to which Professor I. C. White has called attention which are at about the same absolute level, and entirely above the regular river terraces which have been formed in process of the lowering of the channel. One of the chief differences between these high-level terraces on the two rivers is that those on the Allegheny have granitic pebbles derived from the glaciated region while those on the Monongahela do not. Professor White describes extensive areas where this mantling of what seems like a lacustrine deposit, consisting of pebbles, and deposits of clay sometimes thirty feet thick, containing fresh leaves, characterizes the Monongahela up to a level of from 1,000 to 1,100 feet and there suddenly cease.

Professor Chamberlin maintains that these high-level terrace deposits are merely the remnants of flood plains when the whole drainage level was at that elevation. As a corollary to this he contends that the drainage level was at that height at the time of the first glacial epoch, admitting of the distribution of the granitic pebbles in the Allegheny drift, and that the erosion of the Ohio gorge below that level (i. e. to a depth of about 250 feet for a distance of about 1,000 miles as the water runs) was eroded during the interglacial epoch. To that first epoch he would also attribute the glacial deposits on the south side of the Ohio opposite Cincinnati which I had adduced as rendering it probable that there was an ice dam across the river at that point. Professor Chamberlin, on the contrary, supposes these deposits to have been made so much earlier than those a short distance north of Cincinnati that the interval is marked by the whole erosion of the gorge of the Ohio through its whole extent.

I was not present at the discussion of the Cincinnati ice dam at the Geological Society a year ago. But, from what has been published since, it is evident that the last word has not yet been said about it. Mr. Leverett in particular has attempted to correlate some of the clay and lœss deposits in southeastern Indiana, with deposits of similar character in Illinois, attributing both to

the earlier glacial period during its slackened drainage. But he does not seem to have duly considered the facts which I have presented making probable an obstruction of the channel of the Ohio near Madison, Indiana, in Jefferson and Ripley Counties which might well account for the facts in that part of the state most like those in Southern Ohio. (See Bull. U. S. Geol. Surv., 58, pp. 65, 66.) Something more than similar microscopical results must be relied on to demonstrate chronological identity of deposits.

The theory of a somewhat prolonged obstruction of the channel at Cincinnati by ice has received strong confirmation in Professor James's investigations, going to show that the preglacial channel of the Ohio ran at Cincinnati still farther north, following up the valley of Mill Creek until it joined the Big Miami near Hamilton. At any rate it is certain that the Ohio did not in preglacial times flow in its present channel from Cincinnati to the mouth of the Great Miami, for I am informed by Mr. Charles J. Bates, inspector of masonry for the Cincinnati Southern Railroad whose bridge crosses the river just below the city, that bedded rock was found by him a few feet below the present bottom of the river extending across its whole width. But at Hamilton in the valley of the Miami where the depression of Mill Creek joins it, the rock bottom is as much as ninety feet below the level of the bottom of the Ohio at Cincinnati. This northern bend of the river in preglacial times adds greatly to the argument from direct evidence of a prolonged ice dam there. The gorge for several miles below Cincinnati is comparatively narrow and its erosion in good part may perhaps measure postglacial time.

In all this discussion it should be borne in mind that we cannot assume an absolutely constant level of the land in the region of the Upper Ohio Valley. Indeed, the subsidence proved by the Champlain deposits to exist at the close of the ice age involved a differential in the depression of the land to the north which is very suggestive, while another class of facts, equally suggestive of considerable changes of level in connection with the glacial period, appears in the northerly slope of the bed of many northern tributaries of the Upper Ohio and Allegheny rivers. The Shenango, Mahoning and Beaver rivers, and French, Oil and Conewango creeks, all have a rock bottom which slopes to the north, or away from their present outlets. Mr. Carll and some others have argued from this that there must have been a system of northern outlets into Lake Erie in preglacial times. (2nd Penn. Geol. Surv. iii, pp. 330 to 366.) The actual existence of such northern outlets has, however, not been proved by direct evidence. The theory of a general elevation of the country to the north in preglacial

times, such as is supposed to have brought on the period would seem to provide a natural explanation. But Mr. Leverett, under guidance of Professor Chamberlin's theory of the course of events in the Upper Ohio is compelled to resort to the hypothesis that a part of this lowering of the channels of these streams to the northward was done by subglacial currents of water forced by hydraulic pressure to run up hill to find exit. (See this Journal, Sept. 1891, p. 209.) A theory driven to such extremities cannot be said to be altogether free from difficulty.

A simple statement of the rival theory concerning the course of events in the Upper Ohio Valley is its own best defence. I suppose that the erosion during early Tertiary times had proceeded so far that base levels had become established, and that the rock shelves at Bellevue and Parker mark the flood plain of the river at that time. During the close of the Tertiary period the land underwent elevation until it stood much higher than now over all the northern part of the United States and Southern Canada. During this time the rivers lowered their beds to the extent shown by their present rock bottoms. The channel of the Ohio was a product of that period. The differential northerly elevation permitted the erosion of the northern tributaries of the Ohio spoken of. Their present attitude is the result of subsequent differential subsidence. This subsidence occurred in connection with the climax of glacial conditions when the ice extended so as to dam up the Ohio at Cincinnati. This dam coöperated with the slack drainage attending the differential subsidence to produce many of the phenomena which Prof. Chamberlin attributes to a first glacial period. Floating ice came down the Allegheny River in great quantities and drifted into the oxbows and upon the shelves of the earlier epoch of erosion, and left the glacial material which is found in such places as Parker and Bellevue. Similar conditions in the Monongahela favored the deposits of pebbles and silt at the high levels described by Professor I. C. White. The deposits in Teases Valley between the Kanawha and the Ohio in West Virginia probably belong to a somewhat later stage when the barrier below Cincinnati had been worn down to a considerable extent. For it should be observed, that the preglacial channel of the Ohio at Cincinnati toward Hamilton was permanently closed by glacial deposits.

The Columbia terraces of the Susquehanna and the Delaware were deposited under somewhat similar conditions. There was a depression of the coast level of about 200 feet in New Jersey allowing the great ice rafts loaded with Medina bowlders which came down the river to tide level to be floated over the lowlands of the state south and east of Trenton, and to be stranded along the shore on the west side of Philadelphia

to a height of 175 feet. The subsidence to the north was so much greater than that at the south that the drainage of these rivers was much slacker than now, but nowhere do the terraces of this period on the Delaware and Susquehanna rivers extend much above 175 feet except inside the region actually covered by glacial ice. How much these rivers have lowered their beds since that time it is difficult to tell, but probably not a great deal.

I cannot well close this part of the discussion without reference to a recent attempt of Professor Winchell (Am. Geologist, Aug. 1892, pp. 69 to 80) to measure the length of the interglacial epoch in Minnesota. Professor Winchell presents strong evidence to show that the preglacial channel of the Mississippi above St. Paul ran in a nearly straight line with the lower valley and reached the present valley again seven or eight miles north of Minneapolis. This he supposes to have been filled up during the first glacial epoch, while in the interglacial epoch the channel that has long been known west of Minneapolis was eroded, to be filled on the advance of the last glacial ice sheet. This amount of work he estimates would not have required more than 9,750 years, which would be the length of the interglacial epoch in that latitude. Though this is as nothing to the length of the period as estimated by Professor Chamberlin for the southern part of the glaciated area, it is sufficiently long to make us ask whether the data are sufficient by which he would establish the different ages of those preglacial channels? The aspect of the unglaciated areas where secular erosion is open to inspection is such as to throw much doubt over surface indications in the glaciated region. I should be inclined, therefore, to wait for further light before committing myself unreservedly to the theory in question.

9. The final consideration bearing on the duality of the glacial period is drawn from the successive enlargement and desiccation of Lakes Bonneville and Lahontan, in the arid basin west of the Rocky Mountains. This coincidence is certainly very striking, and the theory that there is a causal connection between the phenomena of the glacial periods and the enlargements of these lakes is very plausible. But in our general ignorance of the causes of local climatic changes such a coincidence should not go far in face of other evidence. There are, for example, successive salt deposits in many regions which indicate local variations of climate equal to anything which can be demonstrated in the great Rocky Mountain Basin, but in geological periods when we have no reason to suspect glacial conditions. That the last enlargement of Lake Bonneville coincided with the glacial period is pretty certain,

but that there were glacial periods to accompany the earlier enlargements is by no means so evident.

Futhermore, as bearing against the duality of the glacial period it may be urged with great force that it is improbable that two periods should so nearly duplicate one another as these two are supposed to have done. To those who maintain the sufficiency of Croll's astronomical cause, however, this is rather an argument in favor. But on the other hand, that cause would also demand a long succession of periods during all the geological ages, and of these we lack sufficient proof; while it would throw the two periods which Professor Chamberlin recognizes back much farther than the facts will admit. It must be said, however, that it is not wholly out of analogy with known earth movements to suppose that there has been, in connection with the glacial period, a succession of oscillations of the earth's crust nearly duplicating each other. Such oscillations seem to have occurred in various geological ages, as for instance during the coal period when the successive coal beds were formed. And indeed, much can be said in favor of the view that such an oscillation, when once begun would perpetuate itself. The loading of one part of the land surface and its consequent subsidence would naturally, if not necessarily, be attended with the elevation of other and perhaps distant portions of the crust. This might secure the beginnings of a glacial period in another hemisphere, which when fully grown, would return the favor, and by its weight cause the earth's crust to bulge out again where it had been depressed. But our knowledge of these matters is too vague to reason on it with any confidence, as is also that of the other causes which have been suggested for the production of the phenomena of the period.

In conclusion it is sufficient to remark that our present state of knowledge on the subject seems so imperfect that it is not conducive to success in investigation to hold any theory as to the unity or duality of the period with great positiveness. Over-confidence on this point at the present time is likely to blind the eyes of the investigator, and to hinder progress, both in the collection and in the interpretation of the multitudinous and complicated facts which everywhere invite our close attention.

ART. XLV.—*A Photographic Method of Mapping the Magnetic Field;* by CHARLES B. THWING.

THE common method of obtaining a cross section of the field of force of a magnet by means of iron filings is very satisfactory when only temporary representations of the field are desired. There has been wanting hitherto a suitable method of making a permanent map of the magnetic field.

A method employed in the physical laboratory at Northwestern University has been found to give results so far superior to any hitherto obtained, that a description of the method employed will probably prove of value to others who may be engaged in the study of the magnetic field.

While studying the magnetic field, it was suggested by Mr. John Lamay that a permanent record of the field could be obtained by securing a map upon blue print paper, exposing to the sun, and washing as usual. The results obtained were beautiful; but it was of course necessary to repeat the process for every copy of the field desired. It at once occurred to the writer that by employing a photographic dry plate, in place of the blue print paper, a negative would be obtained from which any desired number of prints could be made and which would have the additional advantage of representing the figures in their true colors.

Fig. 1. Apparatus employed.

The apparatus employed is shown in fig. 1, which also illustrates the method used in distributing the iron filings and exposing the plate.

For obtaining the field of a bar magnet, the magnet was placed upon a large card, previously marked with concentric circles and parallel lines to facilitate the centering of the magnet. The photographic plate was placed, film side up, directly upon the magnet. The iron filings were held at a distance of a foot above the plate in a bag of loosely woven flannel, from which, by shaking the bag, they could be evenly distributed over the surface of the plate. The plate was then held at two points and tapped gently until the filings had arranged themselves along the lines of force. The room was, of course, up to this point illuminated only by non-actinic light. The exposure was now made by turning the key of an incandescent lamp, supported at a convenient distance directly above the center of the plate. The position of the lamp is a matter of considerable importance, as the light from a gas jet at one side of the plate will cause the filings to cast a shadow and give an incorrect representation of the lines of force. Where an electric lamp is not convenient, nearly as good results may be obtained by holding a lighted match above the plate. It is more difficult, however, to time the exposure correctly by this method, and the match will often so cast a shadow upon the plate as to cause irregularity of illumination. After exposure, the plate is tipped so that the filings may slip off, and the few which still cling to the surface of the film are carefully removed by means of a fine, camels-hair brush. The negative is then developed and fixed in the usual way.

The plates employed should be of a sort to give the strongest possible contrasts. A slow plate such as Carbutt's process plate was found to give most satisfactory results. This plate required an exposure of twenty seconds, when a sixteen-candle power lamp was placed at a distance of eighteen inches from the plate. If a match is employed to illuminate the plate, Carbutt's B 16 may be used, with an exposure of about three seconds, and nearly as good results will be obtained.

For making prints from these negatives, any paper may be employed which will give good black and white tones. I have found the aristotype paper to give beautiful results when printed deeply and toned to exactly the right point Reduced positives from these negatives make very brilliant lantern slides, by means of which a great variety of magnetic fields may be shown to a large audience. The want of such lantern slides for illustrating popular lectures has been felt by the writer and doubtless by many others.

Figures 2 to 5 show typical forms of the field of a bar magnet. To obtain the best results, the bar magnet should be a strong one and of considerable size, since the film is of necessity placed the thickness of the glass plate away from the

magnet, and with a weak magnet the lines will not be sufficiently distinct; especially since it is necessary to employ a considerable quantity of the iron filings in order to make a brilliant negative.

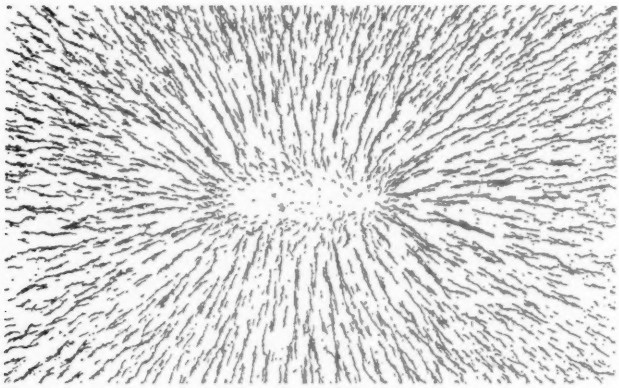


Fig. 2. End of Bar Magnet.

Fig. 6 was made on a 5 by 8 plate with a four inch horseshoe magnet.

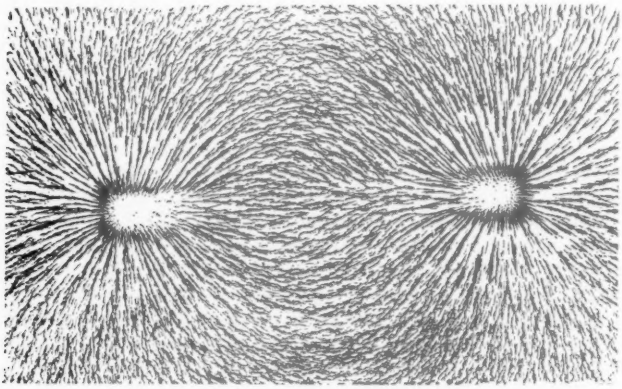


Fig. 3. Bar Magnet.

In fig. 7, six similar eight inch square bar magnets were employed, and placed with alternate poles toward the center. This is the arrangement commonly employed in the fields of an alternating dynamo; and the figure gives a very good idea of the lines of force in such field.

In the preparation of this plate, a marked distinction was noticed between the north and south poles of the magnets. This difference is fairly well shown in the cut.

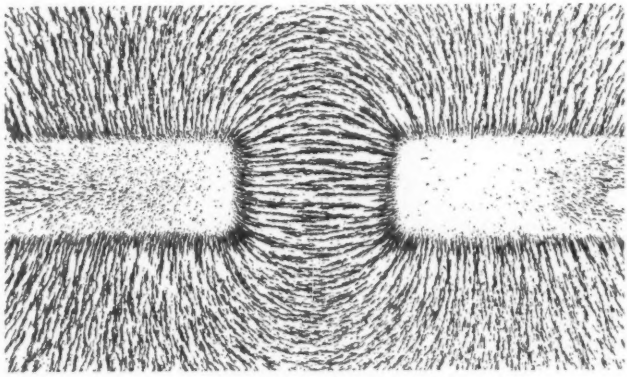


Fig. 4. Unlike Poles.

The alternate poles beginning with the pole upon the left of fig. 7 are south poles. The filings in the neighborhood of these poles are in every case more erect and exhibit greater intensity of action than those at the north poles. Whether this is due to a real difference between the north and south

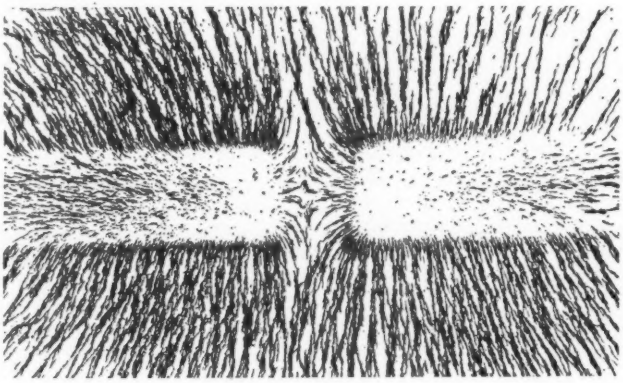


Fig. 5. Like Poles.

poles of the magnet or is to be explained as a mere coincidence, can only be determined by more careful observations than those which I have yet made.

Figure 8 is a representation of the field of a disc magnet, made by magnetizing a small circular slotting-saw of $2\frac{1}{2}$ inches diameter and $\frac{1}{8}$th of an inch thickness. The lines of

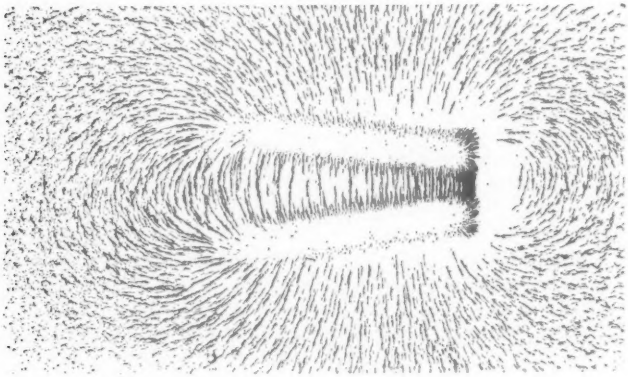


Fig. 6. Horseshoe Magnet.

force bear a striking resemblance to some drawings of the solar corona, and may suggest the correct explanation of that but little understood phenomenon.

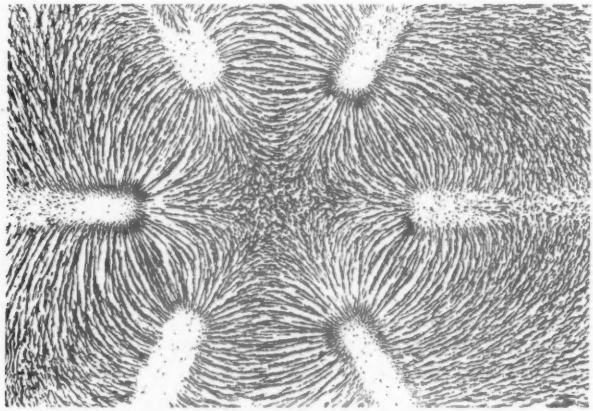


Fig. 7. Alternate Poles.

The remaining figures illustrate sections of fields of various forms of electro-magnets.

Figure 9 is a section of the field of a small motor of the closed field type, and resembles quite closely the field of the

disc magnet shown in fig. 8. The leakage indicated by the lines at the right of the figure is due to the iron base upon which the fields were mounted.

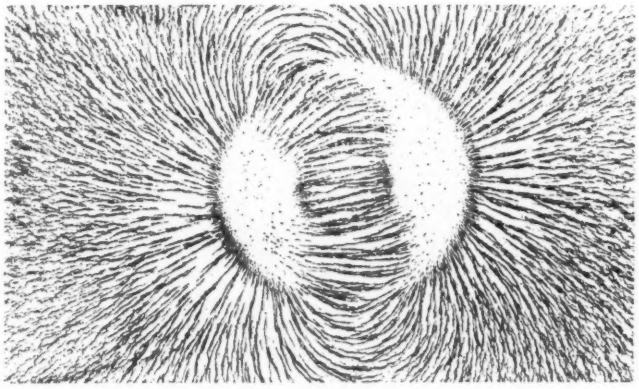


Fig. 8. Disc Magnet.

Figure 10 is the field of a small motor of the common horse-shoe type.

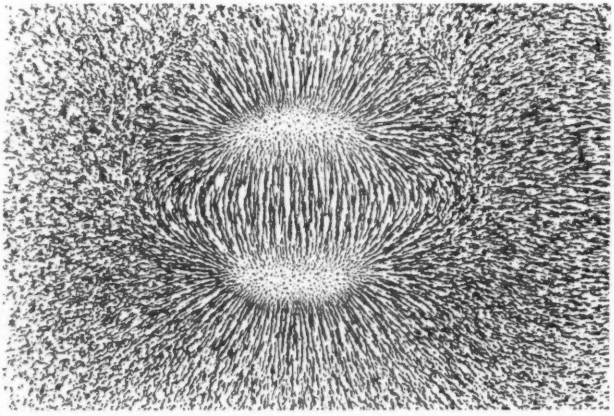


Fig. 9. Motor-Field—Closed Type.

Both figures 9 and 10 were obtained by removing the armature and one bearing so as to make it possible to place the plate within a short distance of the field, at right angles to the armature shaft.

Interesting figures might be obtained by inserting rings between the poles similar in form to the rings of which the armature is composed. These figures illustrate a large class of

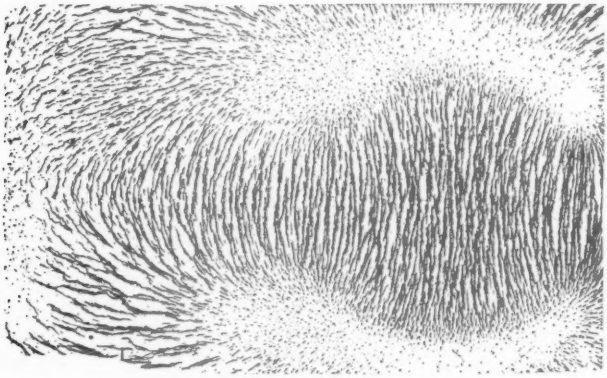


Fig. 10. Motor-Field—Horseshoe Type.

very instructive maps which might be made of the various types of magnetic fields now in use. A careful study of a set of such figures should afford valuable suggestions to the designer of field magnets and transformers.

The motors used in Figures 9 and 10 are shown with the bearings removed in figure 1.

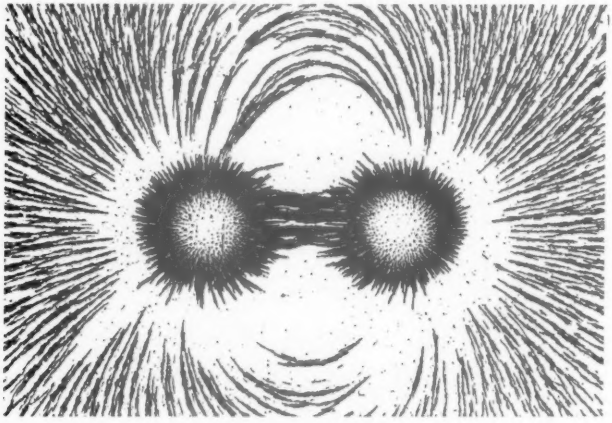


Fig. 11. Electro-Magnet.

Figures 11 and 12 represent the field above the poles of the small electro-magnet shown in figure 1.

In figure 11 the filings in the regions near the poles are drawn to the poles, leaving those regions bare.

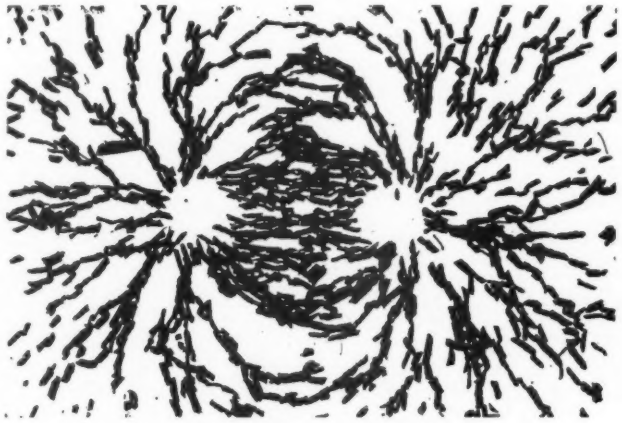


Fig. 12. Electro-Magnet—Iron Chippings.

The somewhat fantastic field shown in figure 12 was obtained from the same electro-magnet by employing coarse iron chippings, instead of the finer iron filings used in the remaining figures. The position of the bits of iron parallel to the lines of force is distinctly shown.

Note.—Since preparing the above, my attention has been called to the excellent article of Professor Houston in the Electrical Engineer for July 20th, in which a method exactly similar to the one here described was briefly outlined. This furnishes another instance of the simultaneous invention of a process by two investigators, each working wholly without knowledge of what the other is doing.

ART. XLVI. — *Contributions to Mineralogy, No. 54;* by F. A. GENTH. *With Crystallographic Notes;* by S. L. PENFIELD.

1. *Aguilarite.*

SINCE the publication of my investigations on aguilarite,* I had an opportunity to examine quite a number of specimens of this mineral. Only a *very few small fragments of pure aguilarite in skeleton dodecahedrons*, like the original, were found among them; most of them were altered, as previously

* This Journal, xli, 401.

described. There were several, however, which deserve a short notice.

a. One variety in irregular flat particles between the cleavage cracks of calcite or calcite and quartz, with a hackly fracture and iron black color had the composition of nearly pure aguilarite (*a*).

b. A second variety made up of small capillary needle- and wire-shaped individuals without any distinct planes, also minute rounded particles, all forming an irregular spongy mass of an iron gray color and metallic luster. Between this are small crystals, not over 5^{mm} in diameter, apparently hexagonal and much resembling forms of polybasite, produced by twinning. The material for the analysis (*b*) was selected with great care, but, as the results show, gave the composition of aguilarite, slightly contaminated with a sulphantimonide.

	a.	*b.*
Ag	79·41	80·27
S	5·93	6·75
Se	13·96	12·73
Cu	0·50	0·07
Fe	----	0·26
Sb	----	0·41
	99·80	100·49

c. Similar crystals, as mentioned under *b*, were found on quartz, associated with calcite, some of them were over 10^{mm} in diameter. On examination with a lens they could easily be seen to be made up of different minerals and were evidently the result of the alteration of aguilarite into stephanite, as previously described, with metallic silver, argentite, etc. The outer portion was brittle, the inner malleable—but neither could be obtained in a state of purity. They gave:

Brittle portion.				Malleable portion.			
Ag	67·58	or Ag_2S	62·85	Ag	84·05	or Ag	25·28
Cu	6·83	Ag_2Se	16·35	Cu	1·83	Ag_2S	55·49
Fe	0·42	CuS	9·27	Fe	----	Ag_2Se	14.28
Sb	6·83	FeS	0·56	Sb	1·24	CuS	2·75
As	----	Sb_2S_3	9·56	As	0·28	Sb_2S_3	1·74
Se	3·51	----	----	Se	3·82	As_2S_3	0·46
S	14·76	----	----	S	8·76	----	----
	99·93		98·59		99·98		100·00

These crystals had been considered to be a *new* species.

d. In the lot of aguilarite specimens was noticed a small piece of quartz and calcite with *solid* dodecahedral crystals, mostly distorted, from 1–2^{mm} in size. As there was no indica-

tion of any cavernous crystals I thought they might show a different composition.

The analysis gave:		Calculated:	
Ag	84·40	Ag	85·06 per cent.
Cu	0·49	S	11·03 "
S	11·36	Se	3·91 "
Se (by diff.)	3·75		100·00
	100·00		

This is the composition of argentite in which $\frac{1}{8}$ of the sulphur is replaced by selenium. The composition corresponding to: $\frac{1}{8}Ag_2Se + \frac{7}{8}Ag_2S$ is given above.

e. A specimen of *acanthite* from Guanajuato, Mexico, presented to me by Messrs. Geo. L. English & Co., was analyzed for the purpose of seeing whether it contained selenium, but was found to be entirely free from it.

Elongated, wirelike distorted crystalline particles in calcite. The analysis gave a trace of quartz and calcite and—

Ag	86·79
S	13·20
	99·99

2. *Metacinnabarite.*

To Professor Gustav Guttenberg of the Central High School at Pittsburg, I am indebted for an interesting occurrence of metacinnabarite in irregular particles of from 5 to 10^{mm} in diameter, disseminated through a ferruginous, laminated barite, from San Joaquin, Orange County, California, where it had been collected by one of his pupils.

Color iron-black, but many pieces show already a partial change into ordinary cinnabarite, both by a good lens and the reddish black powder which some of the particles yield on pulverizing. Fracture conchoidal, brittle, soft. Sp. gr. 7·706. The analysis gave:

Hg	85·89
S	13·69
Cl	0·32
	99·90

It is remarkable that all the fragments which were examined showed the presence of chlorine. The 0·32 per cent of Cl which were found would indicate an admixture of 1·23 per cent of calomel.

3. *Löllingite.*

The arsenide of iron from Halyburton's and Drum's farms which, from qualitative tests, had been mentioned in my Minerals of North Carolina,* as leucopyrite, was found to be löllingite.

A specimen from Drum's farm, Alexander County, mostly oxydized into scorodite, etc., yielded some very pure fragments of from 4 to 6^{mm} in size. They did not show any crystalline faces, apparently amorphous; fracture conchoidal. Sp. gr. 7·031. The analysis gave:

Fe	70·83
Cu	trace
As	27·93
S	0·77
	99·52

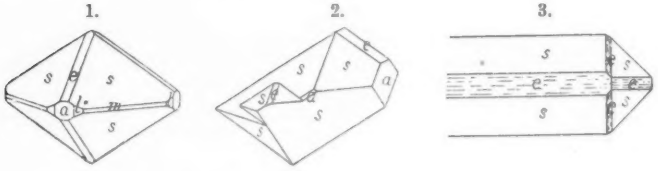
4. *Rutile.*

The flesh-colored orthoclase from West Cheyenne Cañon, El Paso Co., Colorado, contains minute black crystals which were identified by Professor Penfield as rutile.

From the specimens received by Messrs. Geo. L. English & Co. it appears that these crystals are rarely in contact with the orthoclase, but generally implanted in the more recent quartz, resulting from its alteration and filling its cavities.

The rutile crystals are from 0·5 to 4^{mm} in size.

The forms which have been observed on them are *a*, 100, *i-i*; *m*, 110, I; *l*, 130, *i*-3; *e*, 101, 1-*i* and *s*, 111, 1. Some of the crystals are like fig. 1, a habit which is not common with



rutile but reminds one rather of cassiterite. Many of the crystals have four of the pyramid faces, *s*, larger than the others and developed apparently into monoclinic prisms. Fig. 2 represents one of the distorted crystals in ordinary projection and fig. 3 is a basal projection of another, with a still more pro-

* The Minerals of North Carolina, by Frederick Augustus Genth, Bulletin No. 74, U. S. Geol. Survey, Washington, 1891.

nounced prismatic habit. They are iron-black. Sp. gr. 4·249. The analysis gave, after deducting 0·7 per cent of quartz:

SnO_2	1·40
TiO_2	91·96
Fe_2O_3	6·68
	100·04

5. *Quartz resulting from the alteration of the flesh-colored orthoclase of W. Cheyenne Cañon.*

The orthoclase crystals become rounded and in their decomposition leave cavities which are partially filled with grayish-white porous and cavernous coatings either directly upon the orthoclase or with some space between, filled with earthy limonite. The pure grayish or slightly greenish white material shows a cryptocrystalline structure, dull or with a faint vitreous luster. H.=8; Sp. gr.=2·552.

In appearance it somewhat resembles some varieties of the so-called damourite.

The analysis gave:

Ignition	0·95
SiO_2	96·63
Al_2O_3	0·93
Fe_2O_3	0·85
Na_2O	trace
K_2O	0·46
	99·82

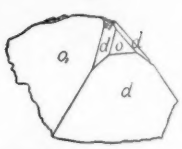
from which it is evident that it is quartz, slightly contaminated with orthoclase.

In the same orthoclase is a mineral in very fine and minute needle-shaped crystals of a greenish yellow color which could not be identified for want of material.

6. *Danalite.*

Among some specimens from W. Cheyenne Cañon, El Paso County, Colorado, which were given to me for identification by Messrs. Geo. L. English & Co. were two fragments, one of a crystal 15×17^{mm} in size, the other not showing any crystalline form. Both were discolored by iron and manganese oxides and were found to be an interesting variety of danalite.

4.



The fragment is part of a modified tetrahedron, having the forms *o*, 111, 1; *o'*, $1\bar{1}1$, -1 and *d*, 110, *i*, fig. 4. One of the dodecahedral faces is larger than the other two and, as it makes a right angle with the large tetrahedral faces adjacent to it, it gives the crystal the appearance of being part of a modified cube.

No cleavage has been observed; fracture uneven, splintery to subconchoidal, color of some portions pale rose color to brownish, owing to slight oxidation. Sp. gr. = 3·626 to 3·661. Luster vitreous.

The material used for analysis was purified by digesting with very dilute hydrochloric acid and had a fine pale rose color, like a deeply colored rose quartz. The mean of two closely agreeing analyses is as follows:

				Mol. ratio.		
Ignition	0·21					
SiO_2	30·26	Si	14·12	·504		2·93
BeO	12·70	Be	4·70	·500		
CuO	0·30	Cu	0·24	·004		
ZnO	46·20	Zn	37·07	·570	1·187	6·90
FeO	6·81	Fe	5·37	·096		
MnO	1·22	Mn	0·95	·017		
S	5·49			·172		1·00
	103·19					
Less O for S	2·78					
	100·41					
O	35·04	2·78	32·26	2·016		11·72

closely agreeing with the formula:

$$(Be, Zn, Fe, Mn)_3Si_3O_{12}S$$

Associated with quartz, astrophyllite and a mineral which appears to be *new*.

7. *Yttrium-Calcium Fluoride.*

On some of the quartz associated with astrophyllite was a mineral in granular crystalline particles. Some fragments show reflections from cleavage planes. White, grayish white and reddish white. H. = 4. Sp. gr. = 4·316.

In the analysis of the best fragment which I could get, a little over one gram, the mineral was decomposed by sulphuric acid, by which the fluorine was expelled as HFl and the little silica as $SiFl_4$. The analysis gave:

		Calculated as fluorides.	Molecular ratio.	
Ignition	1·57			
$(Yt, Er)_2O_3$*	47·58	58·05	·317	
CeO_2	0·83	0·96	·005 ·331	1
$(La, Di)_2O_3$	1·55	1·86	·009	
CaO	19·41	27·03	·347	1
Fe_2O_3 and other admixtures not det.		89·47		

This gives the formula $CaFl_2 . (Yt,Er,Ce,La,Di)Fl_3$.

8. *Altered Zircon or Cyrtolite.*

Messrs. Geo. L. English & Co. sent me for identification crystalline groups of about 10 to 15^{mm} in size. They consisted of bundles of crystals of columnar structure, radiating from a center with their prismatic planes mostly obliterated and terminated by rounded planes of the common pyramid of zircon.

They were stained with a greenish brown coating of the oxides of iron and uranium, and, for purification, had to be treated with dilute hydrochloric acid after which the color is a very light greenish gray. Sp. gr. = 4·258.

Associated with muscovite, flesh-colored orthoclase and quartz, at Mt. Antero, Chaffee Co., Colorado.

The analyses gave:

	a.	*b.*
Ignition	2·42	2·47
SiO_2	30·38	30·66
ZrO_2	61·38	60·89 (by diff.)
Yt_2O_3	0·60	0·65
Fe_2O_3	0·70	0·63
UO_2	4·82	4·70
MnO, MgO, CaO	traces	traces
	100·30	100·00

9. *Lepidolite.*

A very beautiful variety of lepidolite, associated with albite and quartz, from Tanagama Yama, Japan, has been received from Messrs. Geo. L. English & Co. It occurs in crystal-

* The molecular weight of Yt and Er was found to be 126. The oxides were yellow and the sulphates and oxalates slightly rose-colored. Although these results are somewhat unsatisfactory, on account of the contaminated condition and small amount of the material at my command, I thought them of sufficient interest, to place them on record, as great pains were taken to arrive at the most perfect separation of the constituents. Should it be my good fortune to get larger quantities of this mineral, I intend to repeat this investigation.

line plates from 30 to 80^{mm} in size. Professor Penfield says: The form of the plates was not determined. The clear portions show a biaxial interference figure with wide divergence of the optical axes, about like muscovite.

Color grayish white, slightly pinkish, luster vitreous to pearly. Sp. gr. = 2·883. B.B. it fuses readily to a brown glass, coloring the flame intensely a deep red. The analysis, being the mean of two or three determinations, gave:

SiO_2	53·34
Al_2O_3	17·76
Fe_2O_3	3·25
MnO	2·77
MgO	0·05
CaO	0·37
Li_2O	4·60
Na_2O	1·55
K_2O	10·90
H_2O	0·65
Fl	7·78
	103·02
Less O for Fl	3·28
	99·74

The lepidolite plates were all more or less coated with minute brownish white scales, which appeared to be a product of the alteration of lepidolite. With great difficulty I picked out 0·2563 grm. of pretty pure material which gave:

SiO_2	52·91
Al_2O_3	21·15
Fe_2O_3	3·59
MnO	0·94
Li_2O	2·19
Ignition	5·97
Fl, K_2O, Na_2O, etc.	not det.

Therefore not cookeite, but lepidolite altered by hydration.

10. *Fuchsite.*

In a peculiar mica schist, consisting of a gray muscovite with quartz in Habersham County, Ga., occurs associated with chromite and interlaminated with gray muscovite a deep emerald green mica in scales, sometimes from 10–12^{mm} in diameter. Professor Penfield writes me about it as follows: "The fuchsite does not show crystalline outline and the scales are small for optical examination. I observed the following. The sec-

tions show a biaxial interference figure, the divergence of the optical axes being large, about like muscovite. The cleavage plate shows a decided pleochroism, for rays vibrating parallel to **c** bright chrome green, and parallel to **b** yellowish green.

Sp. gr. = 2·983.

The analysis gave:

Ignition	6·04
SiO_2	46·73
Al_2O_3	29·00
Cr_2O_3	2·73
Fe_2O_3	2·59
MgO	3·03
CuO	0·14
Na_2O	0·26
K_2O	9·25
	99·77

Chemical Laboratory, 111 S. 10th St.
Philadelphia, August 29th, 1892.

ART. XLVII.—*The Effects of Self-induction and Distributed Static Capacity in a Conductor;* by FREDERICK BEDELL, Ph.D., and ALBERT C. CREHORE, Ph.D.

THE solution obtained by Sir Wm. Thomson for the variation of the current and the potential at different points in a conductor possessing static capacity is given by Mascart and Joubert, L'Électricité et Le Magnétisme, vol. i, § 233, and is treated at length by Mr. T. H. Blakesley in his book on Alternating Currents. The object of the present communication is to give the solution for the case of a conductor possessing self-induction as well as distributed capacity, and to note the effects produced by the introduction of the self-induction.

The rate of change of the charge on an element of the cable is equal to the difference of the currents flowing into and out from it; and so, writing q for charge and i for current at any time, and x for the distance of any point from the origin—positive direction being that of current flow—we have

$$\frac{dq}{dt} = -\frac{di}{dx}dx.$$

If e is the potential of an element, its charge is $q = Cedx$, where C denotes the capacity per unit length of the cable, and the first equation may be written

$$C\frac{de}{dt} = -\frac{di}{dx}. \tag{1}$$

By Ohm's law the current in an element is equal to the total E. M. F. (the sum of the impressed and that of self-induction) divided by the resistance; and, if R is the resistance per unit length and we assume the back E. M. F. of self-induction per unit length to be equal to the rate of change of the current multiplied by a constant L, we may write

$$i = -\frac{\left(\frac{de}{dx}\,dx - L\frac{di}{dt}\,dx\right)}{R\,dx}. \tag{2}$$

In some cases this assumption may approximately represent the true effect of self-induction, and the results obtained from this particular assumption may show the nature of the effect of self-induction even in cases where the assumption is not justifiable.

The differential equation for potential is obtained by eliminating i from (1) and (2) and is

$$\frac{d^2e}{dx^2} + LC\frac{d^2e}{dt^2} - RC\frac{de}{dt} = 0.$$

The current equation, obtained in the same way, is similar when i is written instead of e.

The general solution of these equations is

$$e = \sum_{h,k} hk\varepsilon^{\frac{R}{Ck^2+L}(t-Ckx)}$$

$$i = \sum_{h,k} h\varepsilon^{\frac{R}{Ck^2+L}(t-Ckx)}$$

where ε is the Naperian base, and h and k are constants to be determined.

If the impressed E. M. F. is harmonic, and at the origin $e = E\sin\omega t$, where ω denotes angular velocity, the solution for the potential at any point of the conductor at any time becomes

$$e = E\varepsilon^{\pm px}\sin(\omega t \pm \alpha x). \tag{3}$$

The solution for the current at any time across any section of the conductor is

$$i = \frac{-E\sqrt{C\omega}}{\sqrt{Im.}}\varepsilon^{\pm px}\sin\left(\omega t \pm \alpha x + \tan^{-1}\frac{p}{\alpha}\right). \tag{4}$$

In these equations Im. denotes the impedance, $(R^2+L^2\omega^2)^{\frac{1}{4}}$;

$$p=\sqrt{\frac{C\omega}{2}}\sqrt{\text{Im.}-L\omega}\,;\ \text{and}\ \alpha=\sqrt{\frac{C\omega}{2}}\sqrt{\text{Im.}+L\omega}.$$

The solutions in equations (3) and (4) show that the potential and current are propagated in harmonic waves whose amplitudes decrease with the distance from the origin according to a logarithmic decrement. At any point of the conductor the potential and current vary as simple harmonic functions of the time with constant amplitudes which are different for every point of the conductor. The current wave is propagated in advance of the potential wave by an angle θ such that $\tan\theta=\frac{p}{\alpha}$. This phase difference diminishes with increase of frequency when there is self-induction, but becomes a constant angle of 45° when L=0. The wave length is $\frac{2\pi}{\alpha}$ and the rate of propagation is $\frac{\omega}{\alpha}$. The wave length and rate of propagation each become less as the self-induction increases. The wave of higher frequency will have the shorter length and be propagated the faster. This difference in rate of propagation of waves of different frequencies is most marked when there is no self-induction.

The distance at which the amplitude decreases to $\frac{1}{\epsilon}$th of its value is $\frac{1}{p}=\frac{\lambda}{2\pi\tan\theta}$; the time for the decrease is $\frac{1}{\omega\tan\theta}$. The rate of decay is most rapid when there is no self-induction. The waves of higher frequency decay more rapidly than those of lower frequency; when there is no self-induction this difference in the rate of decay is the greatest.

The difference in the rates of propagation and decay of waves of high and low frequency doubtless constitutes the limitations to the use of the telephone. As the several harmonic components of a complex tone advance along the conductor, they keep shifting their relative phases according to the difference in their rates of propagation, and also change their relative intensities according to the difference in their rates of decay, thus changing the resultant combination tone and materially altering its quality. These effects are always present in circuits containing distributed static capacity but are not so marked when there is also self-induction.

Physical Laboratory of Cornell University, July, 1892.

Art. XLVIII.—*The Quantitative Determination of Rubidium by the Spectroscope;* by F. A. Gooch and J. I. Phinney.

[Contributions from the Kent Chemical Laboratory of Yale College—XVIII.]

In a recent paper issued from this laboratory* the possibility of determining small amounts of potassium quantitatively by means of the flame spectrum was demonstrated. The work which we are about to describe was performed in the endeavor to see how far similar methods might be applicable to the quantitative determination of rubidium. It was shown in the former work that hollow coils of platinum wire may be adjusted to hold definite amounts of liquid and that, by taking care to plunge the coil while hot into the liquid and to remove it from the liquid with its axis inclined obliquely to the surface, it is possible to take up constant amounts through a long series of experiments. It thus becomes possible to bring definite amounts of any soluble substance into a flame to be viewed spectroscopically. The potassium salt best adapted to spectroscopic use proved to be the chloride, and it was found to be advantageous to dry the coils over a hot radiator before introducing them into the flame. A large Muencke burner gave the best sort of flame, an ordinary single prism spectroscope provided with an adjustable slit (the width of which we were able to fix by closing it upon wires of known diameter) and an observing telescope moveable so that different portions of the spectrum might be shut out at will, served sufficiently well for the work. The coils were made of No. 28 platinum wire (0·32^{mm} in diameter) wound in about thirty turns to a spiral 1^{cm} long by 2^{mm} in diameter and twisted together at the ends to form a long handle. With the apparatus described it was found possible, under the most favorable conditions, to recognize the characteristic red line of the potassium spectrum when only $\frac{1}{1000}$ mg. of potassium, in the form of the chloride, was brought to the flame. It appeared, furthermore, that a comparison of the brightness of two spectra produced in close succession could be made with all the accuracy to be anticipated in photometric measurements, and that therefore by gradual dilutions and successive testings a solution of potassium chloride of unknown strength could be brought to the point of containing as much potassium to the coil-full (and so, of course, to the cubic centimeter or any other chosen volume) as a standard solution of known strength. By noting the final

* Gooch and Hart; this Journal, xlii, p. 448.

volume to which such an unknown solution was brought in the process of equalizing its spectrum with that of the standard its total contents in potassium was determined. In this manner the strength of solutions of pure potassium chloride proved determinable with accuracy, but when the effect of intermixing pure sodium chloride with the potassium salt was studied it transpired that the brilliance of the potassium spectrum was markedly increased by the presence of the sodium in the flame, the maximum increase, which amounted to twenty per cent, appearing when the ratio of sodium chloride to potassium reached 100 : 1. It was found, however, that the practical difficulty of determining potassium in presence of sodium could be largely overcome by taking the precaution to bring the test solution and the standard to apparent equality as regards the potassium line, then to bring the solutions to an equality in respect to the sodium line by addition of sodium chloride to the standard, and finally to readjust the volumes of test and standard until the potassium lines were again equal. The accuracy of the determination of the potassium is, however, in spite of the precaution, somewhat affected by the presence of sodium,—the error, though, sometimes falling as low as $\frac{1}{10}$ mg. in 10 mg., rising occasionally to 1 mg. in 15 mg. With the excellent gravimetric method which we possess for the determination of potassium recourse would, naturally, never be taken to the spectroscopic method except in cases when the determination of small absolute amounts are concerned, but in such cases the spectroscopic method may prove a convenience.

In the work upon potassium the observations of the red line were made in the ordinary laboratory in diffused light, but preliminary experimentation upon the rubidium spectrum immediately developed the fact that the blue lines are better to work by in the case of this element, and that a dark room becomes a necessity. For the experiments to be described pure rubidium chloride was prepared by many fractional precipitations by alcohol out of aqueous solutions, and in settling the question as to the coils which should be used the choice fell upon the size holding 0·02 grm. of water and made of the No. 28 wire, the superior stiffness of these and consequent constancy in capacity giving them the advantage over smaller coils of finer wire, though the latter are capable of bringing out greater sensitiveness of the reaction. We found, for example, that under the most favorable conditions as to height of flame and width of slit, 0·0002 mg. of rubidium chloride produced the blue lines at the last limit of visibility when the larger and heavier coil was in the flame; with a coil holding 0·006 grm. of water and made of very fine wire the more

immediate volatilization of the chloride so increased the delicacy of the spectroscopic reaction that it was possible to see the lines from 0·00005 mg. of the salt. These figures serve as an indication of the possible delicacy of this method of producing spectra, but it should be remembered that all eyes do not see the rubidium lines with equal ease.

In experimenting with rubidium sulphate in place of the chloride the lighter coil appeared to lose its advantage in point of delicacy of the indication over the larger coil, possibly because the amount of metal introduced into the flame has less influence upon the rate of vaporization of the less volatile sulphate, and the lines of the sulphate appeared equally distinct and of longer duration than those of the chloride; but, while we judged the sulphate to be rather preferable in qualitative work, our earlier preliminary quantitative experiments led us to abandon it for the purposes of our investigation on account of the great uniformity in the lines yielded by the chloride. We found it desirable in comparative tests of brightness to employ as the standard the lines given by amounts of the chloride not exceeding 0·0005 mg. to 0·0007 mg., to set the slit at a width of 0·2^{mm}, and to bring the coils to the flame in sets of three—the first, usually a standard, serving to fix the position of the lines so that the comparative distinctness of the lines given by the other two might be the more readily determined. The tables below contain the record of an attempt to dilute a solution of the pure chloride to the strength of the standard solution under the guidance of comparative tests of the brilliance of the spectral lines yielded by the residue left upon the wires after the evaporation of the solutions taken up by coils of equivalent capacity. Dilutions were made in ordinary graduated cylinders of suitable capacity.

EXPERIMENT I.

Standard. Rubidium in a coil-full ($\frac{1}{50}$ cm^3).	Test (known to contain 10 mg Rb.). Volume in cm^3.	Line of test compared with standard.
0·0005 mg.	200	Brighter.
" "	300	Brighter.
" "	350	Brighter.
" "	370	Brighter.
" "	390	Brighter.
" "	400	Brighter (faintly).
" "	400	Brighter (faintly).
" "	400	Doubtful.
" "	410	Brighter (faintly).
" "	410	Weaker.
" "	420	Equally bright.
" "	420	Weaker.
" "	430	Invisible.

When the volume of the test-solution reaches 400 cm³ the indications are, on the whole, that the solution is still stronger than an equal volume of the standard; and when the volume amounts to 420 cm³ it is safe to conclude from the indications that the test-solution is the weaker. If the mean of the numbers representing these two volumes be taken as probably indicative of the volume at which the test and standard lines are at an equality we have the estimated amount of rubidium in the test-solution given by multiplying the volume in cubic centimeters by the number of coil-fulls in 1 cm³ and the product by the amount of rubidium contained in a coil full of the standard solution—$410 \times 50 \times 0{\cdot}0005 = 10{\cdot}25$ mg. The amount of rubidium actually taken in the test-solution was 10 mg., and the error of the mean value assumed is 2·5 per cent+, between extremes corresponding to an error of 0 and 5 per cent +, respectively.

EXPERIMENT II.

Standard. Rubidium in a coil-full ($\frac{1}{50}$ cm³.)	Test (known to contain 10 mg. Rb.). Volume in cm³.	Line of test compared with standard.
0·0005 mg.	340	Brighter.
" "	370	Equally bright.
" "	370	Brighter.
" "	390	Weaker.
" "	390	Weaker.

Found $\frac{370 + 390}{2} \times 50 \times 0{\cdot}0005 =$ 9·5 mg.

Taken ..... 10·0 "

Error ..... 0·5 " = 5 per cent.

EXPERIMENT III.

Standard. Rubidium in a coil-full ($\frac{1}{50}$ cm³).	Test (known to contain 10 mg. Rb.). Volume in cm³.	Line of test compared with standard.
0·0005 mg.	300	Brighter.
" "	360	Equally bright.
" "	380	Brighter.
" "	380	Brighter.
" "	390	Brighter.
" "	400	Weaker.
" "	410	Weaker.

Found $\frac{390 + 400}{2} \times 50 \times 0{\cdot}0005 = 9{\cdot}875$

Taken ..... 10·

Error ..... 0·125 = 1·25 per cent.

These results make it plain that when the comparison is made between solutions of pure rubidium chloride the spectroscopic method is capable of yielding fair approximations to truth. In the practical determination of rubidium, however, the question of the effect of the presence of sodium and potassium which naturally accompany it is of importance. Attention was therefore turned next to the consideration of this point, and the record of observations as to the influence of sodium upon the brightness of the rubidium spectrum is contained in the accompanying tabular statement.

Standard. Rubidium in a coil-full ($\frac{1}{50}$ cm^3).	Test solution. Sodium in a coil-full.	Comparison of lines of test by pairs.	Comparison of lines of test with standard.
0·00066 mg.	0·00026 mg.	Slightly brighter.	Brighter.
	0·00260 "	Slightly fainter.	
" "	0·00130 "	Equally bright.	Brighter.
	0·00260 "		
" "	0·00260 "	Equally bright.	Brighter.
	0·00520 "		
" "	0·00260 "	Brighter.	Brighter.
	0·00660 "	Fainter.	
" "	0·00260 "	Brighter.	Brighter.
	0·00780 "	Fainter.	
" "	0·00260 "	Brighter.	Brighter.
	0·01500 "	Invisible on account of glare.	Invisible.

It appears that within limits the presence of sodium in the flame increases the brilliance of the rubidium spectrum. The brightness of the lines is raised under the conditions to a maximum by the presence of sodium to forty per cent of the weight of the rubidium, and increase in the amount of sodium does not further influence the brightness of the lines until the proportion of sodium to rubidium is as ten to one; or, speaking broadly, the difference between the dissociating effect of sodium upon the rubidium chloride (to which we attribute the effect noted) does not appear to be materially different whether one or a score of molecules of sodium chloride are present to one of the rubidium chloride. But when the proportion of sodium to rubidium much exceeds ten to one the glare of light diffused through the entire spectrum (though the sodium line itself may be cut off) begins to affect the vision, and as the increase advances ultimately extinguishes the rubidium lines utterly. The degree of increase in brilliance when the lines are at a maximum was determined by diluting the test-solution until a coil-full gave a line equally brilliant with that of the standard.

Standard. Rubidium in a coil-full ($\frac{1}{60}$ cm^3).	Test solution. Rubidium in a coil-full with $\frac{1}{10}$ of its weight of sodium.	Line of test compared with standard.
0·00066 mg.	0·00066 mg.	Brighter.
" "	0·00048 "	Brighter.
" "	0·00046 "	Brighter.
" "	0·00044 "	Equally bright.

It is plain that at the maximum degree of brilliance the sodium is responsible for an increase of fifty per cent in the brightness of the lines.

The details of similar experiments in which potassium chloride was introduced into the flame with the pure rubidium chloride are given in the accompanying tabular statement.

Standard. Rubidium in a coil-full ($\frac{1}{60}$ cm^3).	Test solution. Potassium in a coil-full.	Comparison of lines of test taken by pairs.	Comparison of lines of test with standard.
0·00066 mg.	0·00020 mg.	Slightly fainter.	Brighter.
	0·00040 "	Slightly brighter.	
" "	0·00020 "	Fainter.	Brighter.
	0·00340 "	Brighter.	
" "	0·00040 "	Equally bright.	Brighter.
	0·00066 "		
" "	0·00040 "	Brighter.	Brighter.
	0·00340 "	Fainter.	
0·00066 mg.	0·00066 "	Equally bright.	Brighter.
	0·00132 "		
" "	0·00066 "	Brighter.	Brighter.
	0·00246 "	Fainter.	
" "	0·00066 "	Brighter.	Brighter.
	0·00660 "	Fainter.	
" "	0·00066 "	Brighter.	Brighter.
	0·01320 "	Fainter.	
" "	0·00066 "	Brighter.	Brighter.
	0·02000 "	Fainter.	Equally bright.
" "	0·00066 "	Brighter.	Brighter.
	0·02660 "	Fainter.	Equally bright.
" "	0·00066 "	Brighter.	Brighter.
	0·03340 "	Fainter.	Equally bright.
" "	0·00066 "	Brighter.	Brighter.
	0·03340 "	Invisible.	Invisible.

From these results it appears that the presence of potassium produces an effect upon the rubidium lines similar to that of sodium; and, furthermore, the addition of 0·0004 mg. of potassium in the form of chloride to 0·00066 mg. of rubidium also in the form of chloride brings out the maximum brightness which is not materially changed by further addition of

potassium up to about 0·0013 mg., but that the increase of the potassium to 0·0034 mg. results in diminution of brightness. In other words, it seems that a single molecule of potassium chloride has approximately the same dissociating effect upon the molecule of rubidium chloride in the flame as that brought about by a greater number, that the presence of potassium in the proportion of five parts to one of the rubidium begins to influence visibility unfavorably, that when this proportion rises to thirty to one of the elements (or twenty to one of the chlorides) the lines appear about as distinctly as if no potassium were present, and that an increase of proportion to fifty to one may bring about a sufficient glare of light to reduce the rubidium lines to invisibility. The degree of increase in brilliance due to the action of potassium when that element is present in proportions suitable to induce the maximum effect is shown in the following record.

Standard. Rubidium in a coil-full ($\frac{1}{50}$ cm³).	Test solution. Rubidium in a coil-full with its own weight of potassium.	Line of test compared with standard.
0·00066 mg.	0·00066 mg.	Brighter.
" "	0·00064 "	Brighter.
" "	0·00057 "	Brighter.
" "	0·00049 "	Brighter.
" "	0·00044 "	Equally bright.
" "	0·00040 "	Fainter.

It appears that the presence of 0·00044 mg. of potassium is capable of increasing the brilliance of the lines yielded by 0·00044 mg. of rubidium to an equality with the lines given by 0·00066 mg. of the pure salt; or, that the maximum increase of brightness amounts to fifty per cent.

It is evident, therefore, that means must be found to effect the separation of the rubidium from sodium and potassium, or of bringing test and standard to the same condition as regards the presence of these elements, before any reasonable degree of accuracy can be expected in the spectroscopic determination of rubidium as it ordinarily occurs in nature. The separation from sodium is easily accomplished by the conversion of the salts to the form of chloroplatinates; but for the quantitative separation of rubidium from potassium there is no good method known. The question as to the practical value of the spectroscopic reaction of rubidium for purposes of approximative quantitative analysis resolves itself into the problem as to whether by matching potassium lines as well as the rubidium lines (following the method outlined in the determination of potassium in presence of sodium), and so bringing the lines of test and standard equally under the influence of potas-

sium, it is possible to make the comparison between the rubidium lines trustworthy. It was shown in the former paper that in matching solutions of potassium by means of the red line there is no difficulty; but the convenience of being able to use the spectroscope without readjustment throughout the entire experiment made it desirable to see whether the blue line of potassium might not serve sufficiently well in the comparison. It is hardly necessary to reproduce here in detail the evidence bearing upon this point, but we found as the result that the potassium may be determined by the use of the blue line with an error amounting to 10 per cent or 20 per cent, which, though far greater than that inherent in the use of the red line, admits of the attainment of determinations which should be accurate enough for the present purpose. We proceeded, therefore, to make a determination of rubidium in presence of potassium by the process referred to, the details of which are given in Experiment IV.

EXPERIMENT IV.

Standard solution containing { 0·0005 mg. Rubidium / 0·0015 " Potassium } to the coil-full.

Test solution contained 8 mg. rubidium and no potassium.

Step 1.	Step 2.	Step 3.	Step 4.	Step 5.
Preliminary test for Rb	Preliminary matching of K line.	Rematching of Rb line.	Readjustment of K line.	Final matching of Rb line.
Test at 20 cm³ gave Rb line like standard.	Test at 20 cm³ gave K line like standard when 1 mg. of K had been added.	Test at 35 cm³ gave Rb lines like standard.	Test at 35 cm³ gave K line like standard when 2 mg. were present.	Test at 35 cm³ gave Rb line like standard.

Rubidium found $35 \times 50 \times 0{\cdot}0005 = 0{\cdot}875$ mg.
" taken ..... $= 0{\cdot}8$ "
Error ..... $= 0{\cdot}075$ " $= 9{\cdot}4$ per cent.

It is evident that the percentage error is considerable, but inasmuch as the application of the process would naturally be to the determination of small absolute amounts of rubidium we thought it desirable to go a step further to see whether means are at hand for separating large amounts of potassium from small amounts of rubidium with an approach sufficiently near to completeness to bring the potassium present within the limits allowed by the spectroscopic method. After some experimentation we fixed upon the simplest possible procedure, viz: the solution of the salts in the least possible amount of water, precipitation of the mass of potassium chloride by addition of alcohol, filtration, and the evaporation of the filtrate.

In Experiments V, VI, VII, this mode of working was put to the proof. The amounts of rubidium indicated were dissolved in the form of the chloride in water, 0·1 grm. of potassium chloride was added, and the solution was evaporated and treated as described.

	Rubidium taken in the form of chloride.	Potassium taken in the form of chloride.	Rubidium found.	Absolute error.	Percentage error.
V.	1 mg.	0·1 grm.	0·8 mg.	0·2 mg.	20 per cent.
VI.	2 "	0·1 "	1·7 "	0·3 "	15 per cent.
VII.	1 "	0·1 "	0·9 "	0·1 "	10 per cent.

The error of the process is manifestly large, and only roughly approximate results can be hoped for when large amounts of rubidium are dealt with; but, if the question is the estimation of only a few milligrams of rubidium, it will appear, we think, in view of the fact that the only alternative is an indirect process, that even this great error is not absolutely prohibitive of what may be called fair determinations.

XLIX.—*Notes on the Farmington, Washington County, Kansas, Meteorite;* by H. L. Preston.

Professor Henry A. Ward has just cut several slices from his 136¼-pound Farmington meteorite, which have unveiled some interesting facts.

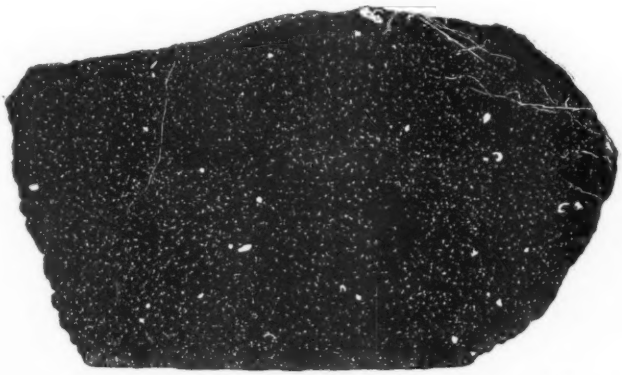
In appearance the slices resemble a section of a dark gray conglomerate (in color much like some trap rocks) with numerous small patches or grains of iron scattered through it, the largest of which is 11x6^{mm} in its greatest diameters.

In the corner of three of these slices there are several veins or fissures extending from 10 to 75^{mm} from the edge of the slice toward the center; and some of these fissures or fractures are filled with iron for 65^{mm} in length from the edge of the slice inward, while in width they are but one millimeter or less.

On the opposite end of the slice there is a very narrow vein, about 90^{mm} long, which for the greater part of the way is filled with iron. Beyond the larger grain or nodule spoken of and these veins, the balance of the iron is scattered rather evenly throughout the mass in comparatively small grains.

For the origin of these fissures and their partial filling up with iron, as seen in the accompanying cut, I would suggest the following explanation:

That, as the meteor struck our atmosphere, the concussion was so great that the mass was fractured in various places, of course extending from the surface inward, and the larger of these fissures or fractures were then filled by the metallic iron which was fused on the exterior surface of the mass, due to its velocity through the atmosphere, and was thus forced in a molten state into its present position, thus forming the metallic veins.



Diagrammatic sketch of slice of Farmington meteorite, showing metallic veins. (½ natural size.)

I have attempted to obtain the Widmanstätten figures on the largest nodule of iron in the mass, but thus far have been unsuccessful.

ART. L.—*A Note on the Cretaceous of Northwestern Montana;* by HERBERT WOOD.

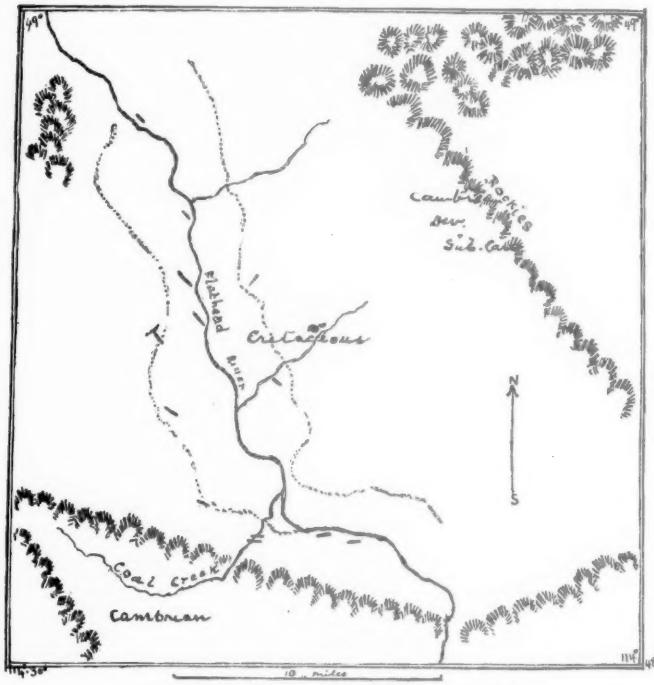
THE geographical position of the Flathead Coal Basin is indicated by the accompanying map, it being a continuation southward of the Flathead Valley, south of the North Kootanie Pass, the Elk River and Crows' Nest Basins* in Southern British Columbia or more particularly Alberta Province. It is the inter-mountain Cretaceous which forms the connecting link between the Cretaceous of British Columbia and Tobacco Plains to the northwest and the Sand Coulee, Bozeman and Rocky Fork Cretaceous† east of the main range or Rockies

* Dawson, G. M.: Report (map) 1886, Can. Geol. Sur.

† W. H. Weed: Engineering and Mining Journal, May, June, '92.

proper in Montana. Exposures of this inter-mountain series are found as far south as the 48th parallel along the banks of the south fork of the Flathead River, also in the vicinity of Marias Pass through the Rockies. Still farther south, a hundred miles or more from the 49th parallel, a younger series of

1.



..... represent the limit of Gravel Deposits.
— represent the Coal Exposures examined.

the Cretaceous has been observed in the vicinity of Missoula extending 18 miles east and west and dipping into the mountains at 30° northwest. It consists of clays, shales and sandstones, with small seams of impure lignite, and capped with a heavy conglomerate, the series resting unconformably on the greatly denuded upturned beds of the Cambrian or Pre-Cambrian rocks which dip south 25°. The valley is a plateau valley from fifteen to twenty-five miles in width and thirty to forty in length, with heavy beds of bowlder and gravel detritus, the grooved and polished rocks (gray quartzites of the Cambrian), on the flanks of the southern range

showing the glacial path as 40° north of west. These gravel deposits, consisting largely of greenish and greenish-black amygdaloidal traps, have a thickness of one hundred to one hundred and fifty feet on the upturned edges of the Cretaceous rocks, their lower portions being formed into beds of calcareously cemented sandstones and conglomerates. The origin of the amygdaloidal trap bowlders is no doubt in the intercalated eruptive rocks of the Cambrian and Cretaceous at the north and south Kootanie passes.* All the valleys of this portion of Montana have a southerly or southeasterly direction exhibiting evidences of glaciation as bowlder clays, lakes behind terminal moraines, and rounded hummocky remnants of ranges, in some cases extending for 150 miles from the boundary or those higher altitudes which existed during or at the close of a supposed epirogenic movement.† The range flanking the valley on the south has a course a little northwest with numerous transverse valleys, and corresponds with the lower Cambrian Quartzitic series or Bow River series, as noted by McConnell.‡ It dips east-northeast under the upturned coal-bearing Cretaceous rocks. The Cambrian here consists of heavily bedded red quartzites changing to sandstones alternating with thinly bedded dark red argillaceous shales, and lower in the series with greenish quartzites of ribbanded character, the upper portion of the series immediately underlying the Cretaceous consisting of greenish gray quartzose slates. The total thickness of this lower Cambrian, i. e., all that below the dolomitic limestone and shales, as given by Dawson§ is 11,000 feet; by McConnell‖ and Walcott¶ 10,000 feet—the latter of whom has recorded his results from the Gallatin section, eastern Montana. A rough traverse made here along Coal Creek gave me 2½ miles of upturned Cambrian rocks. The total thickness of the series as given by Dawson is 29,000 feet.

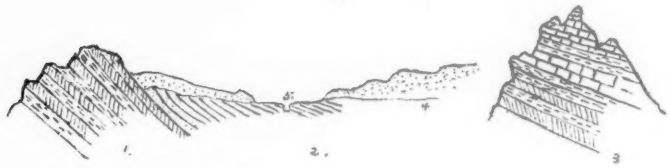
A search was made for fossils but none were obtained, nor does it appear that any were found in this series in southern British Columbia. The dip of the red quartzites is 25° E.N.E., while the dip of the gray quartzose slates immediately under the Cretaceous is 35° to 40° E.N.E., with a strike 20° north of west. Evidences of shore lines were observed in the shape of ripple marks, but no conglomerates or intercalated contemporaneous trappean rocks. The direction of this range is nearly

* G. M. Dawson: Report 1886, pp. 46, 47, 57.
† Upham: Class. of Mount. Ranges.
‡ McConnell: Rep. 1887, C. G. S., p. 29.
§ Dawson: Rep. 1886, C. G. S., p. 51.
‖ McConnell: Rep. 1887, C. G. S., p. 29.
¶ Walcott: Correlation papers Camb. G. Survey. U. S.

east and west while the range west of the Flathead at the boundary has a northwesterly trend, the rocks as noted by Dawson, "greenish close-grained quartzites* and red sandstones" being altogether likely the same geological horizon as those farther south.† He notes, however, farther west "a hard greenish amygdaloidal diorite." If such intercalations are present south of here they escaped my notice.

The Cretaceous beds rest with their upturned edges against the greenish gray quartzose slates of the Cambrian. It constitutes a series of clays, clay shales, coarse and fine-grained sandstones of about 7,500 feet in thickness‡ corresponding with that of the North Kootanie series. At the base of the Cambrian range the dip of the Cretaceous is 50° E N.E. and 1¾ miles north across the strike the dip is 8° and 10° E.N.E., this section at Coal Creek showing the greatly

2.



SECTION AT COAL CREEK.

1. Cambrian.
2. Cretaceous.
3. Camb. Dev. Sub-Carb. (Rockies).
4. Gravel Deposits.
5. Flathead River.

denuded southern margin of a synclinal fold. The basal portion of 1,000 feet of the series is coal-productive, exhibiting 15 or 20 seams of lignite. The upper portion of the series consists of heavily bedded sandstones with shaley partings with some small seams of impure lignite. A phenomenal local thickening§ of the coal seams was observed two miles south-

* Dawson: Rep. 1886, p. 55.

† One hundred miles directly south of this in the vicinity of Missoula, a few fossils were obtained in the siliceous limestone (dolomite) identified by Mr. Chas. Schuchert as Obolella. One or two fossils were found in the red semi-argillaceous slates also but are not yet identified.

‡ This is the result of a tape line measurement and foot traverse made at Coal Creek.

§ Coal	6 inches.	Coal	22 inches.
Clay shale	16 "	Free Sandstone	77 "
Coal	33 "	Coal	3 "
Clay shale	6 "	Clay shale	58 "
Coal	45 "	Coal	40 "
Sandy clay	96 "	Clay	38 "
Coal	2 "	Coal	13½ feet.
Clay	3 "	Clay	21 inches.
Coal	7 "	Coal	48 "
Clay	3 "		

Three additional seams of coal outside the tunnel aggregated 12 feet.

east of Coal Creek canyon at the Emerson Tunnel, thirteen seams being exposed in 150 feet. One seam measured 13½ feet and the combined thickness of the different coal seams equalled 42 feet.

No fossils* were observed in the series nor intercalated traps, ash beds or agglomerates, as noted by Dawson.†

Ten miles northwest of Coal Creek and four miles north of the Cambrian range, a heavy conglomerate of red and green quartzite pebbles (presumably of Cambrian origin) was found. These heavy conglomerates are described by Dawson as occurring at Crow's Nest, Kootanie Passes, and other places—the volcanic horizon occurring apparently above this. My detour did not extend to the boundary, but eight or ten miles south of it. It is not improbable that the upper portions of the series might be found near the line. My observations extended over fourteen miles along the strike of the rocks, and I found that the margin of the fold swings from 12° S. of west at the Emerson Tunnel, through all intermediate variations to 25° north of west, this latter observation being taken 14 miles northwest of the first. This last strike was taken four miles north of the Cambrian, and suggested the assumption of some intervening formations between this and the Cambrian, possibly Devonian.‡ A large number of dips taken throughout the series, gave a gradual variation from 51° E.N.E. to 8° E.N.E. Across the strike of two miles or a little less, a rapid change in dip was noted at the Emerson Tunnel, two miles southeast of Coal Creek. The tunnel is 102 feet in length and gave a variation from back to front of ten degrees—51° to 41° northeast. The presence of the conglomerate, the absence of any evidences of volcanic action, as well as fossils, the relative position in the series of the clays, shales, and sandstones, with a basal coal productive series, as well as the thickness of the whole, seems to correlate these beds with Dawson's series observed at North Kootanie,§ making this region identical with the Crow's Nest valley. The latter beds, however, seem to display a greater variety of fossiliferous forms.

It may be said here that the Bozeman, Cinnabar and Rocky Fork Fields‖ are of Laramie age, while the Sand Coulee is lower in the geological horizon.

The coal is a lignite, exhibiting no changed condition resulting from crushing or violent metamorphic action as shown by

* One fossil plant form was found in a heavily bedded series of sandy clays 30 feet in thickness, 10 miles west of Coal Creek.

† Dawson: Report 1886, pp. 57, 59.

‡ The Report of '86, Can. Geol. Survey, shows the Devonian as crossing the boundary on the west side of the Flathead River.

§ Dawson: Report 1886, pp. 64, 69.

‖ Weed: Engineering and Mining Journal.

the Elk River,* Crows' Nest,† Cascade coal, these being semi-bituminous and anthracitic in character. In these latter instances the flexure is more complex and shows evidences of great crushing and metamorphic action. The coal of Sand Coulee and Bozeman and Rocky Fork,‡ is also bituminous in character—the latter region having been subjected to volcanic action, intercalated beds and dikes of eruptive rocks being a feature, which indeed characterizes many sections of the Cretaceous in the west. The Cretaceous here has not been thus disturbed, the coal being purely lignitic throughout, containing nodules or lumps of mineral resin, presumably succinite or an allied mineral. The series has been subject to lateral squeezing, folding and upheaval which turned the beds up against the Cambrian on the south, and against the Rockies, the Cambrian, Devonian and Sub-Carboniferous on the north.

No examination was made along the north side of the valley for Cretaceous, but the evidence all affirms the supposition of a simple synclinal fold,§ much the same as exhibited at the North Kootanie Pass—the upheaval following at the close of the Cretaceous period. The Cambrian has been subjected at least to two periods of upheaval, if not more, the first being Palæozoic and the last as above mentioned. This is shown in the position of the Cretaceous, one hundred miles south of this resting unconformably on the greatly eroded, upturned edges of the Cambrian,‖ where, however, the Cretaceous has not been subjected to any flexure or folding, but to a slow upheaval or movement of the crust which must have been pretty general in its character.

ART. LI.—*The Deep Artesian Boring at Galveston, Texas;* by ROBERT T. HILL.

AN experimental well has recently been drilled for the city of Galveston, Texas, to the depth of nearly three thousand feet, the results of which are of great value to geologists interested in the sedimentation of the Gulf of Mexico.

Galveston is situated on one of the island sand bars that mark the western border of the Gulf and nearly the entire depth of the drill hole is below sea level. Hence the accom-

* Dawson: Rep. 1886, p. 69.
† Ibid.: Mineral Wealth, Br. Columbia.
‡ W. H. Weed: Eng. and Min. Jour., May and June.
§ Some evidences have been obtained from the descriptive topography of surveyors of minor flexure.
‖ Provisionally given—may be Pre-Cambrian.

panying record is entirely of sediments constituting the present sea bottom.

In the Engineering News of August 11, 1892, Mr. Byrnes, the contractor, published a valuable article on the engineering problems involved, together with the following section illustrating the character and thickness of the sediments passed through up to that date. Work has since been continued on the well and it is no doubt at present down to three thousand feet:

Gray sand	0 ft.
Red clay, with shells	46
Red and blue clay with shells	63
Same with fragments of wood	84 to 100
Gray and reddish sand, with occasional logs,	84 to 100
Red clay and shell of 337	338
Sand with wood and shell	400
Sand and sandy clay to Top of water sand	827
Water sand, 827 to	882
Sand (principally) and clay with wood and shell	882 to 1089
Very hard rock, probably conglomerate	1089 to 1090
Sandy clay and sand to	1260
Water sand 1260 to	1228
Sandy clay, varying hardness Sandstone	
Water sand 1493 to	1510
Clay with shell, pebble and lime	1520
Sand with same clay strata to Calcareous sandstone probably	1754 to 1758
Sand to	1862
Clay (principally) and sand to	2153
Clay with shell and wood fragments	2153 to 2196
Same. Also sand and joint clay to Concretionary limestone, probably	2288 to 2291.5
Sand and joint clay with shell and wood	2349
Water and sand to	2349
Clay and fine sand	2397
Red and blue clay	2425
Water sand	2425 to 2443
Red and blue clay and lignite	2443
Red and blue clay with alternating sand strata	2504
Water sand and blue clay	2504 to 2567
Indurated gray sand to	2598
Blue and red clay, some gravel to Very fine gray sand at	2631 to 2637
Red and blue clay	2653
Pale yellow clay	2698

Blue and yellow clay, and gray sand	2773
Very soft blue clay and reddish clay	2733 to 2871
Coarse sand	2871 to 2863
The drill was in soft clay and fine sand at	2863

No paleontologic data having been given I can only interpret these through my knowledge of the outcrop of the strata on the adjacent coastal plain bordering the Gulf east of Austin and San Antonio. It is said that Mr. Singley, a local observer, has carefully collected the paleontologic data, which it is hoped, he will publish.

In studying the section one is impressed by the littoral character of its material and the absence of indurated or consolidated rock, and the chalky marls and limestones characteristic of the Upper Cretaceous formation, leaving the impression that the 2863 feet of sediments are almost if not entirely composed of post Cretaceous beds.

Every foot of the deposits passed through in the well can be seen in the adjacent outcrops of Texas to-day. These belong to three formations. The provisional interpretations I would place upon the well are as follows:

No.	Strata in well.	Formation.	Age.
1	0–827	Coast Prairie Beds.	Pleistocene.
2	827–1754	Fayette Sands of Penrose.	Pliocene Miocene.
3	1754–2653	Lignitic Eocene.	Eocene.
4	----------	----------	----------
5	2653–2863	Probably Eocene but may be Upper Cretaceous.	

These formations have been described by Penrose, McGee and the writer. No. 1, the Coast Prairie beds are supposed by McGee to represent the southern stage of the former Columbian formation, and were laid down at marine base-level continuing around the coast into Louisiana, No. 3, is the well known Eo-Lignitic formation of the southern United States, as described originally by Hilgard as the Great Northern Lignite.* Penrose† has shown the general character of the formation in Texas and the writer‡ in Arkansas. It is undoubtedly the direct geographic continuation in part of the Laramie beds of the Rocky Mountain region, as shown by Dr. C. A. White§ and the writer.‖ No. 2—the Fayette Sands—is a more problematical formation. Its general occurrence has

* Agriculture and Geology of Mississippi, Jackson, 1860.

† Preliminary Report on the Geology of the Gulf Tertiary of Texas, from Red River to the Rio Grande. Austin.

‡ The Neozoic Geology of Southwestern Arkansas, Little Rock, 1887.

§ This Journal.

‖ Notes on the Texas New Mexican Region, Bull. Geol. Soc., vol. iii, 1891.

been pointed out by Penrose, but no satisfactory interpretation has been made of its limitations and history. As shown by Shumard* and Cope† it contains the wonderful mammalian vertebrate fauna of the Loup Fork and Equus beds which are supposed to be of Miocene and Pliocene age. Its sediments are identical in many unique characters with those of the formations I have seen in Nebraska and on the Staked Plains containing besides the same vertebrate remains the peculiar opalized wood and quartz grains imbedded in a lime matrix identical with the mortar beds of Kansas described by Hay. It is evidently the coastward extension of the Great Plains formation which, as I have shown, extends over the whole Llano Estacado to the Rio Grande‡ as far as Spofford Junction. Whether this formation was deposited at marine base-level or was laid down upon the land after the manner of deposition now going on so extensively over the arid region of Mexico is an interesting problem. One fact is positive, however, and that is that it represents a period of great aridity which prevailed in Miocene and Pliocene time throughout the region of its occurrence.

These three sheets of sedimentation, representing 827 feet of Pleistocene beds, 927 feet of later Tertiary—Miocene and Pliocene—and 2000 feet of Eocene deposits reveal a great load upon the coastal plain, and each, according to the doctrine of isostasy, would afford a sufficient factor to account for the important movements of their respective epochs.

Could the well go deeper into the 2500 feet of Upper Cretaceous chalks and clays and the 2500 feet of Comanche deposits the total load upon the Gulf's margin since the sea first began its oscillations over the Texas region in Wealden time would amount to 8000 feet.

The oldest and latest of the three divisions into which I have divided the section, the Eocene and Columbian respectively, were deposited in very shallow water under conditions identical with the sedimentation of to-day, while the middle division no doubt represents even as shallow if not shallower deposits but under entirely different climatic conditions. All must represent subsidence, although there were no doubt intervening periods of elevation which can only be interpreted upon the land, according to the methods of the modern school of physical geologists. The total subsidence of the old Eocene shore line, according to this boring has amounted to nearly three thousand feet.

* Trans. St. Louis Academy of Science, vol. ii, 1868, pp. 140–141.

† Various papers of Professor E. D. Cope.

‡ Occurrence of Underground Water in the Texas New Mexican Region. Washington, D. C., 1892.

ART. LII.—*Notice of a new Lower Oriskany Fauna in Columbia County, New York;* by C. E. BEECHER. *With an annotated list of fossils;* by J. M. CLARKE.

I.

IN 1890, while making collections and geological sections in the Becraft's Mountain region of Columbia County, New York, a fauna was discovered by the writer, which in many respects is new to the State. Its affinities are with the Oriskany, but its geological position is below the true Oriskany sandstone. It appears to include a part, at least, of what has been considered as the Upper Pentamerus limestone, and has been referred to the Lower Helderberg group on account of its lithological characters and upon insufficient paleontological grounds. The fauna of the Upper Pentamerus in its original locality (Schoharie, N. Y.) has previously been recognized to contain several species quite distinct from the Scutella, Shaly, and Lower Pentamerus limestones, which represent the typical Lower Helderberg group. Moreover, as the complete fauna has remained unknown and the series has been confused with the underlying Scutella limestone, no exact correlations have been made.

From the fossils now known from Becraft's Mountain and several other localities, it is evident that the relations of the fauna contained in the upper beds of the series above the Scutella limestone and just below the Oriskany sandstone are with the latter, and not with the Lower Helderberg group. This is shown by the presence in these beds of such typical Oriskany species as *Edriocrinus sacculus*, *Pholidops terminalis*, *Leptostrophia magnifica*, *Hipparionyx proximus*, *Leptocœlia flabellites*, *Spirifer arrectus*, *Spirifer arenosus*, *Cyrtina rostrata*, *Rhynchonella oblata*, and *Rensselæria ovoides*. This list has been revised by Mr. C. Schuchert, who has made a careful study of the Oriskany brachiopods.

At Becraft's Mountain the rock is a hard, cherty, arenaceous limestone, weathering into a rotten fine-grained sandstone, preserving the moulds of the fossils or their silicified replacements. On Catskill Creek, near Leeds, as shown by specimens received from Mr. W. W. Dodge, the rock contains less sand, and does not weather into a softer condition. At Port Jervis, N. Y., it is in general still more calcareous, although there are some cherty layers, and many of the fossils are silicified. Here, too, the series is continuous from the Oriskany sandstone down through the trilobite beds of Mather, Horton and Barrett. The arenaceous character of the beds gradually

decreases downwards, carrying the typical Oriskany species into the *Dalmanites dentatus* layers and below, and making the whole series of this group at Port Jervis probably over two hundred feet in thickness, of which one hundred or more belong to the Lower Oriskany. The relations of these beds to the Oriskany was appreciated by Barrett,* who was led, however, to refer them to the Lower Helderberg on account of the occurrence of some doubtful Lower Helderberg species and their stratigraphical position.

In the paper on Becraft's Mountain by W. M. Davis,† the Upper Pentamerus, including the Scutella limestone, is stated to have a thickness of from forty to fifty feet, followed directly by the Cauda-galli shales. At Rondout, he recognized a recurrence of the Shaly limestone above the Scutella beds. The same conditions obtain at Becraft's Mountain, and at the top occur the few feet of cherty and arenaceous beds containing the Lower Oriskany fossils.

The paleontological aspect of this fauna is of much interest, especially on account of the large number of genera and species new to the Oriskany group and species new to science. Even the forms which are characteristic of the Oriskany sandstone above offer slight variations in size and features which enable them to be recognized as from a somewhat older horizon. As a whole, the fauna is transitional. A few of the Lower Helderberg types lingered; others were changed into species intermediate between Lower Helderberg and true Oriskany and Corniferous forms; and new types also appeared, which in the higher rocks reached a greater development. Among some of the new types of structure may be mentioned the coarsely plicate Leptocœlia, the Spirifers with plications in the sinus and the Coryccphalus group of Dalmanites, having the outer margin of the cephalon denticulate. C. E. B.

II.

A preliminary List of the Species constituting the Oriskany fauna of Becraft's Mt., N. Y.

(Names in roman are of species present in the normal Oriskany or *Hipparionyx* fauna of Central New York and the Schoharie Section; for convenience of reference the letters H and D are placed before names of species belonging respectively to Lower Helderberg and upper-Lower, or Middle Devonian types.)

FISHES. 1. Spine of undetermined species.

ANNELIDS. 2. *Spirorbis* sp.

(D) 3. *Autodetus* sp n. This genus is also represented in the Hamilton shales, but by a much larger species.

* Ann. Lyceum Nat. Hist. N. Y., vol. xi, p. 297, 1876.

† This Journal, III, vol. xxvi, pp. 381–389, Nov., 1883.

TRILOBITES. (H) 4. *Dalmanites* sp. n. A. A large *Odontochile* with a series of marginal crenulations about the cephalon, of the character of those in *D. pleuroptyx* of the Shaly limestone and *D. anchiops*, of the Schoharie grit, but more extensive than either. The lateral glabellar lobes are more confluent than in the earlier (Niagara and Lower Helderberg) species. The genal angles end obtusely or in small spines. The pygidium is broad and unusually short, ending in a sharp, angular termination, but not in a spine. Annulations simple and very distinct; about 10 on the axis and 9 on the pleuræ. This is the largest and most abundant of the species. Some of the cephala measure 3½ inches in diameter.

(H) 5. *Dalmanites* sp. n. A. var. This is represented by a series of pygidia similar in annulation to the foregoing but persistently different in much smaller size, more slender form and tapering outline. It is closely similar to *D. micrurus*, of the Lower Helderberg, but less abundantly annulated.

6. *Dalmanites* sp. n. B. Long, slender pygidia with acute but not extended terminal spine. Annulations of axis about 15; of pleuræ, 12. On the axis is a double median row of conspicuous tubercles and there are irregularly scattered tubercles on the pleural ribs. This may be compared in form and ornament with *D. dentatus*, of the Port Jervis series, but it is more abundantly annulated and without the strong caudal spine of that species.

7. *Dalmanites* sp. n. C. A single pygidium, quite distinct from the rest, has a tapering outline, high convexity, broad, acute caudal extremity and strong simple annulations. There are 7–8 annulations on the axis, 8–9 on the pleura, all terminating at a considerable distance from the extremity of the shield. The expression of this pygidium is well defined and suggests in some respects, that of a small, sharply annulated *Homalonotus*.

(H) 8. *Dalmanites* sp.? D. There is evidence of another species of this genus with a pygidium somewhat similar to that of *D. pleuroptyx*.

(D) 9. *Dalmanites phacoptyx*, Hall. This species has heretofore been known only in the Upper Helderberg limestone of the Province of Ontario.

(H, D) 10. *Phacops* sp. n. Heads and pygidia are not uncommon. The form of the glabella is somewhat appressed laterally and is suggestive of *P. cephalotes* Barr. The genal extremities bear a single spinule or tubercle as in *P. Logani*, of the Shaly limestone, and *P. pipa*, of the Upper Helderberg, but the glabella does not show the lateral furrows distinctive of the earlier species of this genus. The segments of the thorax bear nodes at the axial furrows, such as characterize *P. Logani*, though the annulations of the pygidium do not appear to be duplicate as in the Lower and Upper Helderberg species. Some small examples do not have the thoracic nodes and these may represent a distinct specific form.

(D) 11. *Phacops* (*Acaste*) cf. *anceps*, Clarke. This species has heretofore been found only in the Upper Helderberg of the Province of Ontario.

(D) 12. *Homalonotus* sp. Occasional fragments indicate a species of small size, differing from the gigantic *H. major*, occurring in the Oriskany sandstone of Ulster Co.

(H) 13. *Cordania** sp. n. Allied to *C. cyclurus*, Hall, of the Shaly limestone but differing in details of ornamentation.

(H, D) 14. *Cyphaspis* sp. n. Of the type of *C. cœlebs* (Lower Helderberg) and *C. minuscula* (Upper Helderberg) but with proportionately much larger cephalon.

(D) 15. *Proetus* sp. n.? A. A small form of the *P. angustifrons-clarus-Rowi* type.

(D) 16. *Proetus* sp. n. B. A much larger form with highly convex glabella and multiannulate pygidium; of the type of *P. crassimarginatus* of the Upper Helderberg.

(H) 17. *Acidaspis tuberculatus*, Conrad. A characteristic species of the Shaly limestone.

OSTRACODES. 18. *Leperditia* sp. 19. *Primitia* sp.

CIRRIPEDES. 20. *Turrilepas* sp.

(CEPHALOPODS. No representative of these fossils has been observed.)

GASTROPODS. 21. Platyceras tortuosum, Hall. 22. P. nodosum, Conrad. 23. Strophostylus expansus, Conrad. 24. Diaphorostoma ventricosum, Conrad.

* The writer has introduced this name in a paper now in press, for certain American species which have been referred to the genus *Phaethonides*, Angelin.

(D) 25. *Diaphorostoma* sp. n. In external ornament similar to *D. lineatum* of the Hamilton shales.

26. Cyrtolites expansus? (D) 27. *Pleurotomaria* sp. n. 28. *Bellerophon* sp. n.?

PTEROPODS. 29. *Conularia* sp.? 30. *Coleolus* sp.?

(H) 31. *Tentaculites* cf. *elongatus*, Hall. A very large species differing, if at all, from the Lower Helderberg form, in its coarser annulations.

32. *Tentaculites* sp. n. A very slender form, covered with minute, equal and closely crowded annulations.

PELECYPODS. (H) 33. *Actinopteria* cf. *textilis*, Hall. This shell is nearer to the typical lower Helderberg species than to the var. *arenaria* occurring in the *Hipparionyx*-fauna.

(H) 34. *Aviculopecten* of the type *A. Schoharie*, Hall, of the Shaly limestone, but covered with radial ribs in addition to the very fine concentric lines.

35. Megambonia bellistriata, Hall 36. M. lamellosa, Hall (?) 37. *Goniophora* sp. n. (H) 38. *Cypricardinia* cf. *lamellosa*, Hall, of the Shaly limestone. 39. *Conocardium* sp.

BRACHIOPODS. 40. *Lingula* sp. 41. *Orbiculoidea* sp.

42. *Crania* sp. n. A large shell with fine, rapidly bifurcating surface striæ. This is of the type of *C. agaricina* of the Shaly limestone, but larger and more finely striate. Not uncommon. 43. *Crania* sp. n. A smooth species.

44. Pholidops terminalis, Hall. This, and *P. arenaria* both of the Oriskany, are probably but the exterior and the internal cast of the same species.

45. *Pholidops* sp. n. A small species of the type of *P. squamiformis*.

(H) 46. *Orthis perelegans*, Hall, of the Shaly limestone.

(H) 47. *O.* cf. *oblata*. Hall of the Shaly limestone. A small form of this type. 48. *O.* sp? A small, subcircular species.

(H) 49. *Orthothetes* cf. *Woolworthana*, Hall, of the Shaly limestone.

50. *O.* sp. n. A small, very abundant shell, in size and expression suggestive of *O. lens*, of the Choteau limestone, but more variable in form and contour.

51. Hipparionyx proximus, Vanuxem. A single specimen of a very large and typical brachial valve.

52. *Leptæna rhomboidalis*, Wilckens. The Lower and Upper Helderberg form, rather than the Oriskany var. *ventricosa*.

53. Strophеodonta Lincklæni, Hall. (H) 54. *S.* cf. *radiata*, Vanuxem. In some of these shells the radial striæ are sharp and strongly fasciculate, producing an expression similar to that of *S. demissa* of the Middle Devonian.

55. *S.* sp. n. A. A large, strongly arcuate form with fine fasciculate striæ, as in *Rafinesquina alternata*.

(D) 56. *S.* sp. n. B. A small convex form of the type of *S. alveata* of the Schoharie grit.

57. Leptostrophia magnifica, Hall. A small variety.

(H) 58 *L.* cf. *Becki*, Hall. A perplane species with low, irregular, concentric rugæ extending to the anterior margin. The prevailing size of the shell is much smaller than in the Lower Helderberg form. Very abundant.

(D) 59. *L. perplana*, Conrad. Persistently more convex than the middle Devonian form; the difference however is no more than varietal. Everywhere abundant.

(H D) 60. *Strophonella* cf. *Headleyana*, Hall, of the Shaly limestone.

61. *Vitulina?* If this identification, founded on a single internal cast, be correct, this genus appears for the first time on this continent in its normal association with a lower Devonian fauna, as in South America and Africa.

(D) 62. *Chonetes* sp. n. A small shell of the type of *C. coronata*, Conrad.

63. *Chonostrophia* sp. n. Differs from *C. complanta* of the Oriskany in smaller size, greater reversed convexity and distinct fasciculation of striæ. 64. Anoplia nucleata. Hall.

65. Spirifer arrectus, Hall. This abundant species varies considerably in size and plication and frequently suggests the Lower Helderberg S. cyclopterus. 66. S. arenosus, Conrad. 67. S. pyxidatus, Hall. (H) 68. *S. modestus*, Hall, of the Shaly limestone. 69. *S.* cf. *fimbriatus*, Conrad. A sparsely ribbed, coarsely fimbriated shell. Specific relations can not be more closely determined with the material at hand.

70. Cyrtina rostrata, Hall. 71. *C.* cf. *Dalmani*, Hall. of the Shaly limestone 72. *Meristella* sp. n. This shell has many points of similarity with *M. oblata* of the Oriskany. It is, however, a smaller, much more strongly trihedral shell, with the aspect of a gigantic *M. lenta*. 73. *Meristella* cf. *laevis* of the Lower Helderberg. 74. *Meristella* sp n? A large non-sinuate species.

(H) 75. *Trematospira multistriata*, Hall, of the Shaly limestone.

(D) 76. *Cœlospira* sp. n. In size this shell resembles *C. Camilla*, of the Corniferous limestone, while it bears the external ornament of *C. concava* of the Shaly limestone, though the plications are rather more numerous.

(H) 77. *Cœlospira* sp. of the small size of *C. concava* but more regularly plicate. 78. Leptocoelia flabellites, Hall. (D) 79. *L. acutiplicata*, Hall, of the Corniferous limestone.

(H) 80. *Anastrophia* sp. n. A very finely plicate species.

81. Reusselæria ovoides, Eaton. 82. R. Suessiana, Hall? 83. R. ovalis, Hall? 84. Rhynchonella oblata, Hall. 85. R. Barrandii, Hall. 86. R. cf. speciosa, Hall. 87. R. sp.?

(H) 88. *Eatonia medialis*, Hall, of the Shaly limestone. 89. E. peculiaris, Conrad.

(D) 90. *Centronella*, sp. n. of the type of *C. glans-fagea*, but of great size.

(H) 91. *Cryptonella* sp. n. Similar to an undescribed species in the Shaly limestone.

Bryozoans. (D) 92. *Fenestella celsipora*, Hall, of the Corniferous limestone. 93. *F.* sp?

(D) 94. *Hemitrypa* cf. *columellata*, Hall, of the Corniferous limestone.

95. *Polypora* sp? 96. *Reptaria* sp. 97. *Hederella* sp. 98. *Clonopora* sp. 99. *Fistulipora* sp.

Corals. (H) 100. *Zaphrentis* cf. *Rœmeri* of the Shaly limestone. 101. *Z* sp.? 102. *Romingeria* sp. 103. *Monticulipora*, a branching species. 104. *Trachypora*, sp.

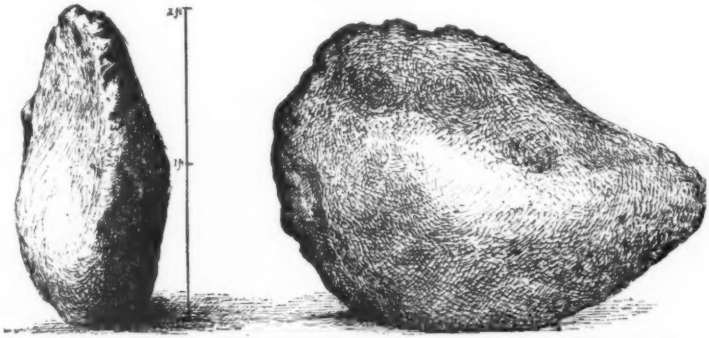
Crinoids. 105. Edriocrinus sacculus, Hall.

Sponges. 106. *Hindia* sp.

This remarkable association of species furnishes the missing link in the evolution of the Lower Helderberg into the typical Lower Devonian fauna. While the presence of so many positive Oriskany types determines the faunal quantivalence, the perdurance of species and modifications of specific expressions characteristic of the Shaly limestone fauna, and the inception of upper Lower Devonian specific forms, render this combination altogether unusual and of prime significance in the correlation of our earlier Devonian. The southwestern extension of the Oriskany (*Hipparionyx*) fauna, as in Maryland, is complicated with the Lower Helderberg, but to a less degree than here; while, in the representative of the same fauna in the Province of Ontario there is a great predominance of Upper Helderberg species. With the 46 species which have been identified in the *Hipparionyx* fauna of New York (see list published by Mr. Charles Schuchert, in Eighth Annual Report of the New York State Geologist, p. 50, 1889), the 106 *or more* species of the Becraft's Mt fauna are in striking contrast, and no element so strongly enforces this contrast or is so unique in itself as the *crustacean*. The association is indubitably of early Oriskany age and is eminently the *Trilobite* or *Dalmanites* facies of the Oriskany fauna. J. M. C.

ART. LIII.—*Description of the Mt. Joy Meteorite;* by EDWIN E. HOWELL.

THE accompanying cut gives a good idea of the form of the third largest meteorite found in the United States, and the largest east of the Mississippi River.



It was found in November, 1887, on or about the 16th of the month, by Jacob Snyder, about a foot below the surface while digging to plant an apple tree near his house, five miles to the southeast of Gettysburg, in the township of Mt. Joy, Adams Co., Penn. It was supposed by the finder and his friends to indicate the near presence of an iron mine, and considerable prospecting was done to locate it. The meteorite was placed on some timbers in the open air where it remained until the summer of 1891, before it was seen by any one who surmised its true character.

Professor F. W. Clarke induced Mr. Snyder to send it to the National Museum for inspection, but was finally unable to secure it, as Mr. Snyder was unwilling to part with it for a price, which the museum felt justified in paying. I, therefore, purchased it from Mr. Snyder on the 15th of August, 1891. The three largest dimensions of the meteorite are 11, 24, and 33½ inches and it weighed on the museum scales 847 lbs. Professor Clarke had a few ounces taken off for examination; with this exception and the scaling of decomposed crust, from the outside, the mass still remains as it was found.

Professor Clarke has kindly furnished me with the following analysis, made by Mr. L. G. Eakins in the laboratory of the United States Geological Survey.

Professor Clarke did not succeed in developing the Widmanstättian figures satisfactorily, and the small amount of nickel shown by the analysis would indicate a poor etching

iron; when larger surfaces are available, we shall doubtless obtain better results.

Fe	93.80
Ni	4·81
Co	0·51
Cu	0·005
P	0·19
S	0·01
	99·325

No idea can be formed of the length of time the meteorite had lain in the ground and very little of the amount of surface decomposition, it has undergone;—sufficient, however, to remove all the finer pittings, leaving a comparatively smooth surface.

Having been much interested in Mr. Davison's examination of the magnetic properties of the Welland meteorite, and thinking that this line of investigation in other meteorites, might lead to interesting results, I requested Mr. Marcus Baker of the U. S. Geological Survey, to make an examination of the meteorite, which he kindly consented to do.

The result of this examination is to show that the meteorite, as a whole, acts as a mass of soft iron, gaining polarity under the inductive action of the earth. The lower portion on the north side became a north-seeking pole, while the upper part became a south-seeking pole; a pretty distinct neutral line was shown, inclined to the horizon at an angle (20°–25°) which is approximately the complement of the local inclination of the dipping needle. This induced polarity shifted with each change in the position of the whole mass, and in general this shifting of the poles took place promptly though not always at once. Mr. Baker also states that his observations suggested the probable existence of an unequal distribution of permanent magnetism, but this matter requires further investigation.

ART. LIV.—*On the Influence of the Concentration of the Ions on the Intensity of Color of Solutions of Salts in Water;* by C. E. LINEBARGER.

THE color of a solution of a salt in water depends upon the color of the ions into which it is decomposed by the act of solution as well as the color of the salt itself. If the salt is colorless and contains but one colored ion, any circumstance tending to increase the number of dissociated ions, tends to intensify the color of the solution. If the salt is colored and

contains one or more colored ions, the colors of the salt and the ions will mix, and the solution will have an intermediate color. Any circumstance causing a change in the state of dissociation of the dissolved salt will change the character as well as the intensity of the solution.

Of course, the more concentrated the solution of a salt, the more intense its color; but there is another way by which the color may be rendered more intense, while the concentration of the salt, i. e. the amount of salt to fixed amount of water, does not change at all. This consists in heating the solution. Abundant experimental proof of this statement is found in an investigation by Gladstone,* "On the Effect of Heat on the Colour of Salts in Solution," which was published in 1857. Let us see why this change of intensity of color should take place in heating a solution.

It has been found that the electrical conductivity of solutions of salts increases as the temperature rises, about 2 per cent for each degree of temperature. In the light of Arrhenius's electrochemical theory this means that salts in solution become more and more decomposed into their ions as the temperature rises; the higher the temperature, the more concentrated the solution *with ions*. Accordingly, as the intensity of the color of a solution depends in a great measure upon the number of ions contained in it, if a colored solution be heated, its color deepens.

Gladstone's paper commences with these pregnant sentences:—"As a general rule, the solution of a salt has the same power of absorbing or transmitting the rays of light at all temperatures. I am not acquainted with any instance of a dissolved colorless salt which assumes a color when the solution is either heated or cooled; nor does the converse seem ever to occur,—a salt colored at the ordinary temperature, which loses that color when heat is applied. Nevertheless it is not rare to find colored salts which, when dissolved in water, vary in shade or in tint according to the temperature.

In some cases, heating the solution seems merely to intensify the color. This is the case with the following red, orange, yellow, and green salts:—

Meconate of iron—red.
Terbromide of gold—red.
Red nitrate of cerium.
Bichromate of potash—orange.
Ferrocyanide of potassium—yellow.
Molybdous chloride—green."

A number of instances are now given of changes in the character as well as in the intensity of the color, when the

* Phil. Mag., xiv, 423.

solution is heated, the change of the character of the color being due, as mentioned above, to the fact that the undissociated molecule as well as its dissociated ions are colored. In reference to these observations he says:—"A glance at the above observations will suffice to show that where the color is not materially altered in character, it invariably becomes more intense when heated, that is to say fewer rays are transmitted; * * * The elevation of temperature seems to heighten the absorbent power of the dissolved salt, so that the light absorbed by a certain quantity of the heated solution is the same as would have been absorbed by a larger quantity of the same solution, if cold."

We now know that this absorbing power is exercised by the ions as well as by the salt in solution, and that just as the color is the more intense the more concentrated the solution, so is it also, the more numerous the dissociated ions. And, to repeat, as heat increases the number of dissociated ions of a salt in solution, so does it deepen the shade of color of the solution.

NOTE.—Just before receiving the proof of the above paper, there came to my notice the articles "On the Dissociation of Electrolytes in Solution as shown by Colorimetric Determinations" (Chem. News, vol. lxvi, pp. 104, 114, 141, 152) by H. M. Vernon, B.A., the experimental data of which afford additional proof of the correctness of the views expressed above.

Chicago, Ill.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Relative Densities of Hydrogen and Oxygen.*—RAYLEIGH has continued his researches on the relative densities of hydrogen and oxygen. In his first paper (1888) he gave 15·884 as the ratio obtained. Subsequently he effected a direct synthesis of water and obtained the ratio 15·89. He says: "I had intended further to elaborate and extend my observations on the synthesis of water from weighed quantities of oxygen and hydrogen, but the publication of E. W. Morley's masterly researches upon the 'Volumetric Composition of Water' (*Amer. Jour. Sci.*, March, 1891) led me to the conclusion that the best contribution that I could now make to the subject would be by the further determination of the relative densities of the two gases. The combination of this with the number 2·0002 obtained by Morley as the mean of astonishingly concordant individual experiments, would give a better result for the atomic weights than any I could hope to obtain directly." In the present experiments, the gases were obtained electrolytically, the generator being a long U-tube containing a solution of potassium hydrox-

ide, furnished with platinum electrodes and supplied with about three amperes of current by means of a Grove battery. Only one of the gases is collected, the other being allowed to escape through a mercury seal. If the hydrogen is to be collected, this gas is led, first, through a tube of hard glass containing metallic copper and heated to redness, thence through a flask containing a strong potassium hydroxide solution, then through a second hot tube containing copper, through a regulating tap and a tube containing solid hydroxide, through a long tube containing phosphoric oxide, and finally through glass-wool. The globe in which the gas is weighed is connected to one terminal of a four-way tube, the other terminals leading to the pump, to the generator and to a blow-off tube of the barometric length, respectively. In making an experiment, gas from the generator was allowed to flow through the purifying train, under the action of the pump, for half an hour. Then the pump was put into communication with the globe and with its set of tubes and a high vacuum produced in them. On making connection with the generator the globe slowly filled with gas, the operation taking from two to three hours. The gas was allowed to escape from the blow-off tube for some minutes, under a pressure of half an inch of mercury. The cistern was then lowered, leaving the end of the tube free, and the flow of gas was continued for two minutes. Four minutes were allowed after the tap to the generator was closed, for equilibrium of pressure to be attained. Then the tap to the globe was turned off, the barometers and thermometers read, and the globe weighed. The finally corrected values obtained were for hydrogen 0·158531 gram, and for oxygen 2·51777; so that the density-ratio is 15·882. Combining this with Morley's ratio of volumes 2·0002 : 1, the value 15·880 is obtained as the ratio of the atomic masses. The following summary of the results of different experimenters is given in the paper:

Name.	Date.	Atomic masses.	Densities.
Dumas,	1842	15·96	
Regnault,	1845	....	15·96
Rayleigh,	1888	....	15·884
Cooke and Richards,	1888	15·869	....
Keiser,	1888	15·949	....
Rayleigh,	1889	15·89	....
Noyes,	1890	15·896	....
Dittmar,	1890	15·866	....
Morley,	1891	15·879	....
Leduc,	1891	....	15·905
Rayleigh,	1892	....	15·882

—*Proc. Roy. Soc.*, Feb. 18, 1892; *Nature*, xlvi, 101, June, 1892.

G. F. B.

2. *On the Properties of liquid Oxygen and liquid Air.*—In a recent lecture at the Royal Institution, Dewar illustrated the properties of liquid oxygen by some remarkable experiments.

Upon the lecture-table stood a liter flask full of liquid oxygen. On filling a test-tube with it, it appeared milky, but became clear on passing it through filter paper. The image of the liquid thrown on a screen, appeared of a pale blue color. The liquid in the tube boiled violently at the temperature of the air, with a hissing noise, giving off a white smoke due to the frozen moisture of the surrounding air. Its boiling point, determined thermo-electrically, is −180°. Liquid oxygen is a non-conductor of electricity. Moreover, a spark $0{\cdot}1^{mm}$ will not pass through it from a coil giving a long spark in air; so that it is also a good insulator. Interposed in the path of a beam of light, its absorption spectrum showed clearly the lines A and B of the solar spectrum, which lines as is well known, are due to absorption by the oxygen in our atmosphere. On accelerating the evaporation of some liquid oxygen by reducing the pressure upon it, Dewar liquefied air in an open test-tube under atmospheric pressure. The liquid air was clearer and fumed less than liquid oxygen. It also boiled more quietly. Common air liquefies at a much lower temperature than oxygen, both gases being liquefied together. In evaporating however, the nitrogen boils off before the oxygen. Placing two or three ounces of liquid air in a test-tube, a smoldering splinter of wood, placed in the upper portion, was not at first ignited. But after the nitrogen had for the most part boiled off, which took nearly five minutes, the wood when immersed burst into flame. He then poured out a wineglassful of liquid air and presented it to Lord Kelvin, who was in the chair. The magnetic properties of liquid oxygen were shown by placing some of it in a cup made of rock salt (in which it assumes the spheroidal state) and putting the cup beneath the poles of a powerful electromagnet. On completing the circuit, the liquid oxygen rose from the cup and attached itself to the poles, thus connecting them together. There it boiled gradually away, sometimes more on one pole than on the other, falling back into the cup when the circuit was opened. With a single pole the oxygen was drawn up out of a tube. Compared with iron, liquid oxygen is about one thousandth as magnetic. Liquid air also goes to the poles of a magnet, there being no separation of the oxygen and nitrogen. It has the same high insulating power as liquid oxygen. Although phosphorus is not attacked on being dropped into liquid oxygen, yet a photographic plate immersed in liquid oxygen at −200° was found to be sensitive to light. Dewar gives the following boiling points under atmospheric pressure: carbon dioxide −80°, nitrogen monoxide −90°, ethylene −103°, oxygen −184°, nitrogen −198·1°, air −192·2°, carbon monoxide −193°, nitrogen dioxide −153°, marsh gas −164°. Under only 5 to 10^{mm} pressure the boiling points are for CO_2 −116°, N_2O −125°, C_2H_4 −142°, O −211°, N −225° (solid), air −207° (solid), CO −211°, N_2O_3 −176°, CH_4 −201° (solid).—*Engineer*, lxxiii, 516, June, 1892.

G. F. B.

3. *On the Industrial production of Liquid Carbon dioxide.*—In a report lately made to the Société d'Encouragement, TROOST has called attention to the extent to which liquid carbon dioxide is prepared for commercial purposes, the chief use in Germany being in the preparation of beer and in France for the preparation of salicylic acid by the reaction of liquid CO_2 on sodium-phenol. At the works of the Compagnie Générale des Produits Antiseptiques, the carbon dioxide is produced by the combustion of coke and is collected in a gasometer; from this it is drawn, dried and compressed into iron bottles under pressures of 5, 25 and 71 atmospheres. Most of it is used in the manufacture of salicylic acid, though it has other uses. At present the daily output is 300 kilograms, but the capacity of the works is to be increased to 1000 kilograms. It is sold at sixty centimes per kilogram. It is used in making aerated waters, in the filtering of wine, for cooling purposes in consequence of the absorption of heat on vaporizing and for producing a high pressure in the solidification of metals.—*Bull. Soc. Enc.*, July, 1892; *Nature*, xlvi, 399, Aug., 1892. G. F. B.

4. *On the Oxidation of Nitrogen by the Spark.*—The production of small quantities of nitrous and nitric acids during the passage of electric discharges through moist air, is well known. LEPEL has undertaken an investigation to determine the precise nature of the chemical changes taking place, with a view of increasing the yield. The first product, when the spark passes through air, apparently, is nitrogen dioxide; which becomes tetroxide by the oxygen of the air. This reacts with the aqueous vapor, forming nitric acid and setting free nitrogen dioxide again, thus: $(NO_2)_6+(H_2O)_2=(HNO_3)_4+N_2O_2$. On further passing the sparks, however, decomposition of the nitrogen oxides into their constituents takes place; so that in a closed space a limit is soon reached beyond which there is no further increase in the production of nitric acid. Hence the author has used a slowly moving atmosphere, varying the pressure and the spark through a wide range; and he has already increased the amount of combination up to ten per cent of the air employed. The best effect is obtained when the air is exposed under increased pressure to a series of parallel spark-discharges in the same tube. The air in the tube is changed intermittently, the gases passing into a large absorption vessel containing water or alkali-solution. In his later experiments Lepel has used a Töpler machine having 66 revolving plates; and he thinks that with the high voltage discharges lately produced by Tesla and others, the problem of producing nitric acid from the atmosphere may be a commercial success.—*Ann. Chem. Phys.*, II, xlvi, 319, June, 1892. G. F. B.

5. *On the Inoryanic synthesis of Azoimide.*—Hitherto, azoimide N_3H has been obtained only from organic substances. WISLICENUS has now effected its synthesis from purely inorganic materials. His method depends upon the interaction between nitrogen monoxide gas and ammonia in presence of sodium.

These two gases do not react upon each other even when a mixture of them is passed over heated soda-lime. But in presence of sodium, action readily takes place, owing to the production first of sodium amide, which then reacts with the monoxide to yield the sodium salt of azoimide, thus: $NaNH_2+N_2O=NaN_3+H_2O$. The sodium salt being less explosive than most of the other salts of azoimide, the experiment may be safely performed if proper care is exercised. The sodium in small pieces is placed in several porcelain boats in a combustion tube and the air is displaced by a current of ammonia gas. On heating the tube the sodium fuses and is converted into sodamide. Then the current of ammonia is replaced by one of nitrogen monoxide, and the temperature is reduced to between 150° and 250°, by surrounding the tube by an air bath. The sodamide increases in bulk and becomes sodium azoimide, the reaction being completed when ammonia no longer escapes. This salt may also be obtained by passing a mixture of nitrogen monoxide and ammonia over metallic sodium; but the yield is smaller and the sodium sometimes inflames in the monoxide. On throwing the product into water, and distilling the filtered solution with dilute sulphuric acid, the distillate possesses the intolerable odor of azoimide and gives precipitates with silver, lead, and mercurous nitrates, which correspond in properties with these salts of azoimide. The silver salt gave 71·7 per cent of silver, AgN_3 requiring 71·8 per cent. Potassium and zinc may also be used in place of sodium.—*Ber. Berl. Chem. Ges.*, xxv, 2084, July, 1892; *Nature*, xlvi, 286, July, 1892. G. F. B.

6. *On Metallic Carbonyls.*—On the 3d of June, a Friday evening discourse on metallic carbonyls was given at the Royal Institution by Ludwig Mond. After referring to the potassium-carbonyl of Liebig as the first metallic carbonyl, he entered upon a consideration of the nickel-carbonyl, discovered three years ago by himself, in connection with Langer and Quincke. The nickel, prepared in a fine state of division by heating the oxalate in a current of hydrogen, is treated with carbon monoxide at a low temperature. The escaping nickel-carbonyl, cooled in a freezing mixture, is condensed to a colorless liquid, which freezes at −25° in needle-shaped crystals. The vapor has a characteristic odor and is poisonous. It decomposes at about 200° depositing a mirror of metallic nickel. Its magnetic properties, according to Quincke, are remarkable since it is diamagnetic to a high degree, all other nickel compounds being paramagnetic. It is also an excellent insulator. Its spectrum, observed by Liveing and Dewar, shows that it is opaque for all rays beyond wave-length 3820. On diluting its vapor with hydrogen, the flame on burning is bright yellowish green and gives a spectrum having a bright background on which are superposed a number of bands. In the ultra-violet fifty well-defined lines are observed corresponding exactly to lines in the spark spectrum of nickel. The magnetic rotation of nickel carbonyl, as observed by Dr. Perkin, is found to

be greater than that of any other known substance excepting phosphorus. The atomic refraction of nickel in this substance is nearly two and a half times as large as in any other nickel compound. In accordance with the view that the valence of an element is higher in proportion as its compounds have a higher refractive power, the valence 8 has been assigned to the nickel in nickel-carbonyl. Ferro-carbonyl is prepared in a similar way. It is an amber-colored liquid, solidifying below $-21°$ to a mass of needle-shaped crystals, and decomposing at 180°. Its formula is $Fe(CO)_5$. It is permanent in the dark but on exposure to sunlight is decomposed, yielding a fine gold-colored solid. Experiments on a somewhat large scale to test the practicability of utilizing nickel carbonyl in the extraction of nickel from its ores, proved entirely successful.—*Nature*, xlvi, 230, July, 1892.

G. F. B.

7. *Rapid Electrical Oscillations.* — In the experiments by Hertz on electrical oscillations and also in the experiments of subsequent investigators, Ruhmkorf coils have been used to propagate the electrical oscillations. It is well known, however, that the oscillation in the sparks from a Holtz machine or a Leyden jar are far more rapid than those produced by the aid of a Ruhmkorf coil. TOEPLER, therefore, has endeavored to study electrical oscillations by the aid of a Toepler-Holtz machine. His attempt has met with success and he describes his experiments at length in the paper we cite. His conclusions state the ratio between the primary and secondary circuits which he employed in order to produce the phenomena of resonance. He also studied the electric spark between a conductor and a surface of water, and discovered that this spark did not oscillate and he therefore concludes that it is probable that the ordinary lightning discharge does not oscillate. A loud noise and strong development of light in an electric spark is not in general a criterion of oscillatory character of the spark.—*Ann. der Physik und Chemie*, No. 7, 1892, pp. 464–484; No. 8, 1892, pp. 642–665. J. T.

8. *Electricity of Waterfalls.*—PH. LENARD refers to the opinion formerly held upon this subject, and after an exhaustive examination conducted in the Alps and also in the laboratory, concludes that drops of water which fall upon water or wet bodies develop electricity. The water is positively electrified. The air moves away from the place of the fall of the drops charged negatively. The charge of the water can become so great as to produce small sparks. The air potential in a room can become strongly negative. Slight impurities in the water have very great effect upon its electrification. A simple explanation is afforded by the hypothesis that contact electricity is developed between fluid and gaseous bodies.—*Ann. der Physik und Chemie*, No. 8, 1892, pp. 584–636. J. T.

9. *Photography of Color.*—At a meeting of the Physical Society in Berlin, June 17, 1892, H. W. VOGEL read a paper on the various attempts which have been made to reproduce

natural colors by photography. He pointed out that the Lippmann process requires great care in the preparation of the bromide of silver emulsion in order to obtain the layer of finely divided silver which is essential to the success of the Lippmann process. Moreover there is no possibility of the multiplication of copies of the photograph. Each copy requires an exposure and a separate development. A resumé is then given of the endeavors of various workers to combine three negatives taken through red, yellow and blue glass. Later investigators employed (in 1869), red, green and violet. Suitable plates of the required sensibility, however, could not be obtained. In 1873 Vogel prepared orthochromatic plates of greater sensibility and an advance was made in the representation of the values of colors. Further improvement has been made in orthochromatic plates and in the method of using suitable color screens. What formerly could be accomplished by chromo-lithography after a month's labor by the employment of twenty stones can now be done in eight days with only three plates.—*Ann. der Physik und Chemie*, No. 7, 1892, pp. 521–527. J. T.

10. *Electrical Resistance of Allotropic Silver.*—A. OVERBECK has examined the resistance of the new forms of silver discovered by M. Carey Lea, of Philadelphia. The latter has shown that allotropic silver can be converted into the ordinary silver in the following ways:

1. By heating.
2. Mechanical means (pressure).
3. By intense light.
4. By electrical discharges.
5. By treatment with different acids and solutions of salt.

Overbeck finds that all operations which tend to approximate allotropic silver to ordinary silver lessen its electrical resistance. The electrical resistance proves to be a very sensitive reagent, far more sensitive than any chemical process, to show differences of molecular state.—*Ann. der Physik und Chemie*, No. 6, 1892, pp. 265–280. J. T.

11. "*On the Simultaneity of Magnetic Variations at different places on occasions of Magnetic Disturbance, and on the relation between Magnetic and Earth Current Phenomena;*" by WILLIAM ELLIS. (Abstract.)—In this paper the author refers to the ordinary variations of the magnetic elements as observed at Greenwich; the annual progressive change; the diurnal variation—large in summer, small in winter, and also larger when sun spots are numerous and smaller when sun spots are few; the irregular magnetic disturbances and magnetic storms, and the accompanying earth currents; phenomena which are generally similar at other places.

He then invites attention more particularly to magnetic disturbances. Those at Greenwich may, after a calm period, arise gradually, or commence with great suddenness. When sudden, the movement is simultaneous in all elements. The first indication

may be a sharp, premonitory, simultaneous movement, followed after a time by general disturbance, or the movement may at once usher in the disturbance. These initial movements are not always great in magnitude, sometimes, indeed, small, but they have a very definite character, and frequently occur nearly instantaneously, as is shown by the character of the photographic traces.

It has been long known that magnetic disturbances occur at the same time over wide areas of the earth's surface, but the accidental comparison in past years of the times of commencement of one or two disturbances at Greenwich with the times at other places has led the author to suppose that the coincidence in time is much closer than had been before supposed, and the definite, and on occasions isolated, character of the initial movement induced him to undertake the collection and comparison of the times of such movements for a number of days at observatories geographically widely separated.

The times of such movements cannot be caught by eye observation without continuous watching of the magnets, so that the photographic registers have to be relied upon, which is better, excepting that the scale of time is necessarily contracted; but, though in individual measures there might be variations, it was conceived that (supposing no systematic error to exist) the mean of a number of comparisons should give a good result. Seventeen days occurring in the years 1882 to 1889 were selected for comparison, the observatories being those of Toronto, Greenwich, Pawlowsk, Mauritius, Bombay, Batavia, Zi-ka-wei, and Melbourne, and, for a less number of days, Cape Horn (as obtained from the Mission Scientifique du Cap Horn, 1882–83.) It was desired to have times for Pola, but it was found that photographic registers during great part of the period did not exist. The variation in time at each place from the mean of times for all places is given for each day. The mean deviation at the different places varies from $+2{\cdot}4$ minutes to $-2{\cdot}9$ minutes, the agreement between four of the places, Greenwich, Pawlowsk, Mauritius, and Bombay, being very much closer, the mean values of deviation for Greenwich, Pawlowsk, and Bombay differing, indeed, by only $0{\cdot}1$ minute, equivalent to 6 seconds.

The question arises, Are the differences real, or due (considering the contracted time scale) to accidental error? If the magnetic impulse is really simultaneous over the whole earth, it is a striking physical fact, and if not entirely so, the circumstance is no less interesting; but greater attention to accuracy of time scale, or a more extended scale, may be necessary before the point in question can be definitely settled.

A table is added, showing the character of the magnetic movement at the several observatories, from which it appears that at any one place the movements on different days were in most cases similar, though different at different places, indicating on these occasions the occurrence usually of one general type of disturbance.

Reference is made to the question of earth currents. A comparison for thirty-one days, between 1880 and 1891, of cases of sudden magnetic movement and earth current, shows the earth current to precede the magnetic movement by 0·14 minute, equivalent to 8 seconds. The question of the relation between magnetic movements and earth currents is discussed. The desirability of being able temporarily to obtain, when occasion requires, a more extended time scale for all magnetical and meteorological phenomena is pointed out.

The general result is that in the definite magnetic movements preceding disturbance the magnets at any one place are simultaneously affected; also that in places widely different in geographical position the times are simultaneous, or nearly so, a small constant difference existing at some places which may be real or may be accidental, but the character of which it seems desirable to determine. It is shown also that at Greenwich definite magnetic movements are accompanied by earth current movements which are simultaneous, but that neither magnetic irregularities nor ordinary magnetic variations seem to admit of explanation on the supposition of being produced by the direct action of earth currents.—*Proc. Roy. Soc.*, No. 313, p. 445.

12. *Physics, advanced course*, by GEORGE F. BARKER, Professor of Physics in the University of Pennsylvania. 902 pp. 8vo. New York, 1892 (Henry Holt and Company.)—The subject of Physics has grown to so large proportions of recent years that to present it adequately, in systematic shape and with such thoroughness as the higher grade of students demands, is a work of ever increasing difficulty. To the accomplishment of this task Professor Barker has brought a thorough grasp of the subject as a whole, a comprehensive and minute acquaintance with the writings, both practical and theoretical, of the foremost workers and thinkers in the science, and an unusual degree of skill and experience in the clear presentation of facts and principles for the benefit of students. The results of his labors, the careful and patient nature of which are obvious from beginning to end, is a work modern in method and fresh in matter, not indeed beyond criticism at some points, but which commends itself to the attention of every teacher who has to do with this department.

Physics in general is treated as "the science of energy" and the three fundamental divisions adopted for the subject are those of (1) mass-physics, (2) molecular physics and (3) physics of the ether. In the first division the subjects discussed are kinematics, dynamics, work and energy, attraction and potential, also the properties of matter and finally the energy of mass-vibration or sound. The second part includes heat; while the third gives the discussion of radiation in general: of electrostatics, called the energy of ether-stress; magnetism, "the energy of ether vortices"; electrokinetics, "the energy of ether flow". The last chapter treats of the electromagnetic character of radiation.

The above classification will serve to show the point of view adopted by the author, which he has systematically followed throughout the development of the different parts of the subject. There is thus a unity of general treatment which adds much to the value of the work. The book is also consistent in minor points, as in the use of the units adopted, in employing diagrammatic illustrations instead of pictorial representations of elaborate apparatus and in other respects. It is compactly printed, so that the large amount of matter included is embraced in 900 pages; the reader could wish, however, that a little less compression had been used by the printer at some points, for the printing of analytical expressions in the body of the text detracts much from their clearness, especially as first presented to the mind of the student.

The ultimate test of the adaptability of a text book to the purposes of general instruction must always be its actual use in the class-room, and it is to be hoped that this new Physics may here meet with the success which the author's careful labor makes it merit.

II. Geology and Mineralogy.

1. *Geological Survey of Texas*, 3d Annual Report for 1891, E. T. Dumble State Geologist. 410 pp. 8vo, with maps and plates.—This volume, after the general Report of the State Geologist, contains papers on Houston Co., and on a section from Terrell to Sabine Pass, by W. Kennedy; on the Llano Estacado with a geological map and notes on the geology of the country west of the Plain, by W. F. Cummings; on the Triassic in northwestern Texas, by N. L. Drake; on shells of a northern character in a dry salt lake near Eddy, New Mexico, by V. Sterki; on the Cretaceous of Texas, north of the Colorado River, by J. A. Taff; on Trans-Pecos Texas, by W. H. Von Steeruwitz. On the map of the Llano Estacado the general surface is made Tertiary, on the basis of the fossil Vertebrates found in surface deposits. In the southern part of the Plain there are Cretaceous beds, and beneath these and along a large part of its border, Triassic beds, as described by Mr. Drake. The Vertebrate fossils of the Llano Estacado, here described by Prof. Cope (and also in the Proceedings of the Amer. Phil. Soc. 1892, p. 128), occur in Crosby County, in a white diatomaceous deposit, the so-called Blanco beds. They are species of *Equus*, *Mastodon*, *Creccoides* (a new genus of birds), and *Testudo: Equus simplicidens* Cope, *Mastodon angustidens* (or a related species), *Creccoides Osborni* Cope, and *Testudo turgida* Cope. The Blanco beds are regarded as older than the Equus beds and newer than the Loup Fork, the latter containing *Mastodon angustidens* but no species of *Equus*. The specimens described for the Survey by Professor Cope were collected by Mr. Cummins.

2. *Geological Survey of Alabama*, by E. A. Smith, State Geologist. Bulletin No. 3, On the lower gold belt of Alabama

by William B. Phillips. 98 pp. 8vo, with a map. 1892.—The gold belt described occurs in the counties of Chilton, Coosa and Tallapoosa.

3. *Annual Report of the Arkansas Geological Survey for 1892*, vol. i. 152 pp. 8vo.—This volume consists of a report on the Iron Ores of Arkansas by Dr. R. A. F. PENROSE.

4. *On the Osteology of Poëbrotherium, a Contribution to the Philogeny of the Tylopoda.* 74 pp. 8vo, with 3 plates: *On the Osteology of Mesohippus and Leptomeryx, with Observations on the mode and factors of Evolution in the Mammalia.* 104 pp. 8vo, with 2 plates; by W. B. SCOTT, College of New Jersey, Princeton. From the Journal of Morphology, v, Nos. 1 and 3, Boston, 1891.—These papers are the first and second parts of a Memoir bearing on questions in mammalian evolution. The osteological character of Poëbrotherium, Mesohippus and Leptomeryx are presented in detail after a thorough study of the large collection at Princeton, and made the basis of comparisons between them and the near and more distantly related species in and near the successional lines severally of the Camel, Horse and Tragulus. The specimens in the Museum include a nearly complete skeleton of *Poëbrotherium labiatum* of Cope, from the White River beds, a restoration of which is given, and also numerous bones illustrating the other genera. From his critical study, Prof. Scott draws conclusions as to the changes which took place in the course of development, and thence deduces principles as to "the modes and factors in the evolution." His method is the only right one, and it is used with great caution and excellent judgment. The closing part of his chapter on Evolution takes up the question as to *factors;* and in the introductory remarks he expresses his dissent from Weissmann's theory of the continuity of the germ-plasm, and says that in his opinion "so far from rendering the phenomena of heredity more intelligible, it tends to confuse them still further, and to end logically in a system very like the old preformationism. As Lloyd Morgan has very pithily put it, 'I cannot but regard Weissmann's doctrine of the continuity of germ-plasm as a distinctly retrograde step. His germ-plasm is an unknowable, invisible, hypothetical entity, material though it be, it is of no more practical value than a mysterious and mythical germinal principle.'" Prof. Scott in summing up the results of his examination says, that it is clearly seen "that transformation, whether in the way of the addition of new parts, or the reduction of those already present, acts just *as if* the direct action of the environment and the habits of the animal were the efficient cause of the change, and any explanation which excludes the direct action of such agencies is confronted by the difficulty of an immense number of the most striking coincidences."

5. *On Palœaspis of Claypole.*—A paper by Mr. Claypole on his genus *Palœaspis* was read before the Geological Society of London on the 22nd of June. In it he "describes two specimens from the Onondaga group (referred to the Lower Ludlow), which

indicate the existence of a ventral plate. The fossil which he described as *P. bitruncata* is maintained to be the Scaphaspid plate of *P. Americana*." The genus is compared with other Pteraspid genera, and a restoration in accordance with his conclusions is given.—*Ann. Mag. Nat. Hist.*, Oct. 1892, 334.

6. *Devonian fossils from the Islands and vicinity of Lakes Manitoba and Winnepegosis*, by J. F. WHITEAVES, Canada Geological Survey.—Mr. Whiteaves enumerates and describes a large number of Devonian fossils from North-Central America and illustrates them with many lithographic plates. The species are in part identical with those of the United States. But a considerable number are new; and they are of unusual interest also "on account of the close relations brought out in many respects between the fauna of these rocks and that of the Devonian rocks of Europe." The collections were made by Mr. Tyrrell and the author of the papers, and the localities are laid down on Mr. Tyrrell's "geological map of Northwestern Manitoba, and portions of the districts of Assiniboia and Saskatchewan," recently published by the Canadian Survey.

7. J. P. IDDINGS: "*The Eruptive Rocks of Electric Peak and Sepulchre Mt., Yellowstone Nat. Park.*" *Annual Report U. S. Geolog. Survey, Vol. XII.*—The writer presents the result of his studies on groups of igneous rocks occurring in the northwest corner of the Park. At Electric Peak occurs a stock of diorite accompanied by a great number of dikes and of sheets extensively intruded into Cretaceous strata. These rocks are described in considerable petrographical detail with tables of variation in structure and in chemical and mineralogical composition. From this it is shown that the variations in all directions are most gradual and transitional and that it is impossible to distinguish sharply differentiated types. The rocks of Sepulchre Mountain, a series of andesitic dikes cutting breccias, are treated with like results and the relationship of the two occurrences shown. Then follows a discussion of the bearing of the observed facts on theoretical petrography: the writer establishes that the same magma under differing physical conditions produce rocks mineralogically different. In conclusion the subject of classification is touched upon and the writer expresses himself in favor of a system based on crystalline structure. The paper is ably written and a most important contribution to petrographical literature. L. V. P.

8. A. SAUER: (*Mittheilungen der Grossh. Badischen Landesanstalt. II. Bd.*)—In a petrographical and geological study of "The Granite of Durbach" the author describes a peculiar syenite of lamprophyric character which surrounds the granite as an outer zone and to which he gives the name of Durbachite. Particularly interesting are the author's researches on the chemical composition of the hornblende of this syenite. This obtained in a state of great purity and freshness yielded 2·72 per cent of water by the Sipöcz-Ludwig method, although over the blastlamp

and heating to incipient white heat only 1·63 per cent could be obtained, regard being paid to the oxidation of the ferrous iron present. The water being considered as basic the analysis showed the mineral composed of a mixture of $RSiO_3$ and $\overset{III}{R}_2SiO_5$ silicates and as a result of his work the writer urges that more attention should be paid to the determination of water in hornblende analyses, since small quantities escaping determination may cause great differences in the molecular formulæ, on account of its low molecular weight. L. V. P.

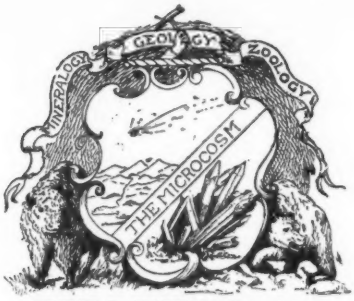
9. *Danalite from Cornwall.*—The occurrence of the rare mineral danalite at Redruth, Cornwall, has been recently described by Miers and Prior (*Min. Mag.*, vol. x, p. 10). The only specimen thus far known was obtained in 1864; it shows a group of large reddish crystals of tetrahedral aspect which were formerly supposed to be pseudomorphs of garnet after tetrahedrite. The danalite is associated with quartz, small crystals of arsenopyrite and sphalerite. The hardness of translucent crystalline fragments of a columbine-red color is 5·5; the specific gravity is 3·350. An analysis gave the results in 1, while a new analysis of the Schwarzenberg helvite gave the numbers in 2; from the latter a little fluorite has been deducted.

	SiO_2	FeO	MnO	ZnO	BeO	CaO.	S	
1.	29·48	37·53	11·53	4·87	14·17	*tr.*	5·04 = 102·62	
2.	33·33	4·45	44·43	..	14·92	..	5·03	Al_2O_3 0·77 = 102·93

A new occurrence of danalite from Colorado is described with analysis by Genth and Penfield on p. 385 of this number.

10. *Mineral Resources of the United States*, Calendar years 1889, 1890. David T. Day, Editor, 671 pp. Washington, 1892 (U. S. Geol. Survey, J. W. Powell, Director).—The seventh volume of this valuable series has recently been issued and like its predecessors gives a careful review by competent writers of the mineral industries of this country; the period embraced by the report covers the years 1889 and 1890. It is announced that the volume for 1891 is also well under way.

Temperature of the Circumpolar region.—A short paper on the temperature of the Circumpolar regions, by Jules Girard, along with a map, is contained in the Bulletin of the Société de Géographie of Paris, for the 2nd trimester of 1892. It is based on the International observations during the year, August 1882 to August 1883, and the reports furnished by the expeditions. There were 15 stations occupied by the several nations—the United States, England, Germany, Denmark, Austria, Sweden, Norway, Holland and Russia—which took part in the observations.



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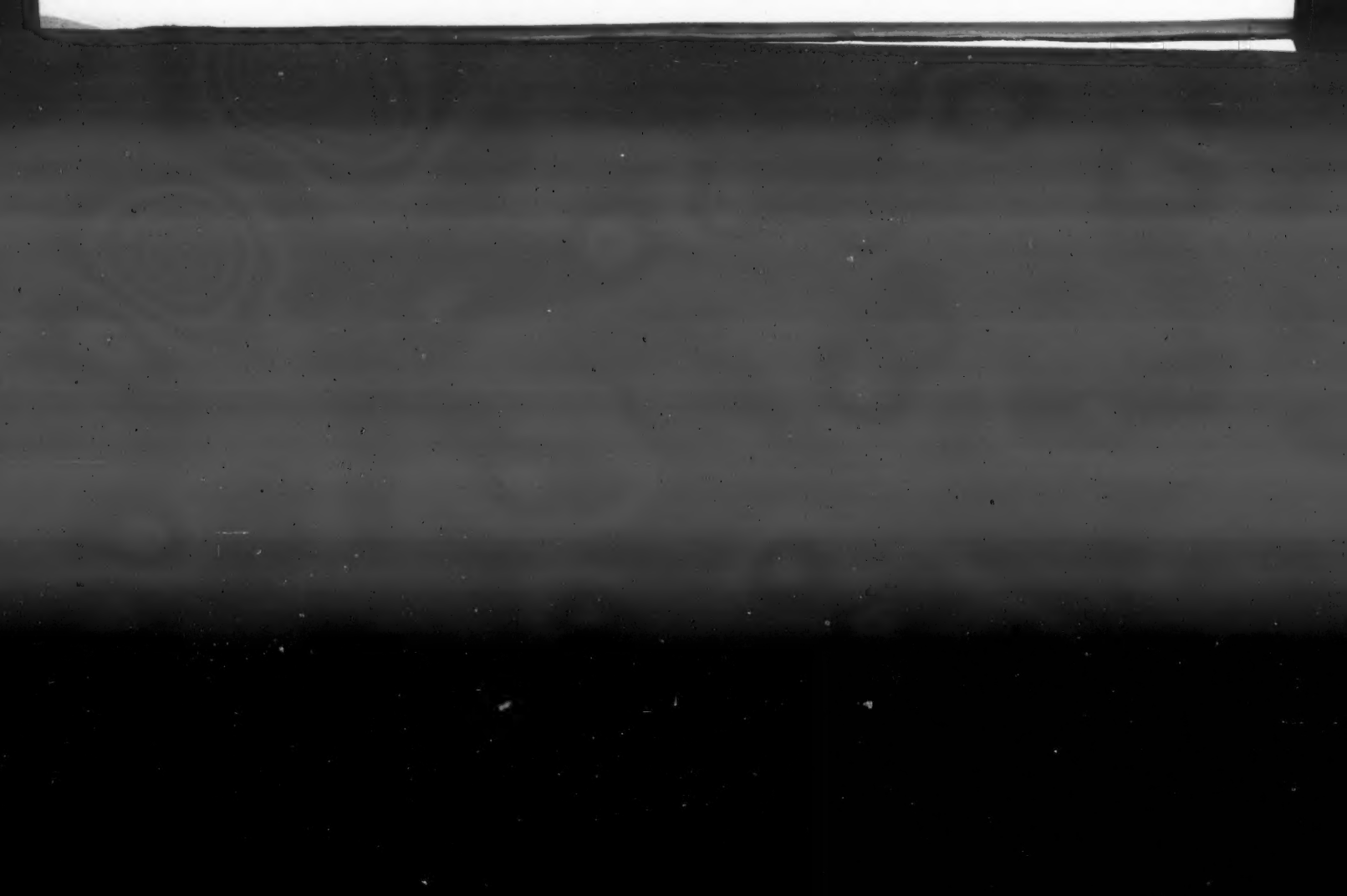

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